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OCTOBER 2020 #485

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- Single WAN series LTE routers support failover functions between xDSL/Ethernet/LTE connections for Vigor2620L, or between Ethernet/LTE connections for VigorLTE 200n.

Vigor2862 LTE Series

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- 4G LTE Multi-WAN router with SIM card slot
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- Central VPN Management
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

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- 1 x GbE WAN ports, 1 x configurable GbE WAN/LAN port, 1 x USB port for 3G/4G LTE Modem
- SPI Firewall, 802.11ac Wave 2 Wi-Fi
- 16 x VLANs, 50 x VPN tunnels (including 16 x SSL-VPN tunnels)
- Central VPN Management
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

Vigor2620 LTE Series

Aust/NZ VDSL NBN Ready | Ethernet WAN NBN Ready | Ethernet WAN UFB Ready | DUAL SIM | 2x VPN

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- VDSL2/ADSL2+, 1x configurable GbE WAN/LAN port
- 1 x GbE LAN port
- SPI Firewall
- 802.11n Wi-Fi
- 2 x VPN tunnels including SSL-VPN
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

VigorLTE 200n

Ethernet WAN NBN Ready | Ethernet WAN UFB Ready | DUAL SIM | 2x VPN

- 4G LTE router with dual SIM card slots (SIM slot 2 for failover)
- 1x configurable GbE WAN/LAN port
- 1 x GbE LAN port
- SPI Firewall
- 802.11n Wi-Fi
- 2 x VPN tunnels including SSL-VPN
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

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EDITORIAL

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EDITORIAL

Meanwhile...

In *APC* news.

Welcome to another fine issue of *APC*, and the exciting world of technology we cover. This month there's a bit of housekeeping to attend to. We've needed to bump up the cover price by a dollar, beginning with this issue. Increasing costs have forced this, and we've held it off as long as we possibly could – indeed the last time *APC* saw a price rise was way back in 2012. It's now an unavoidable necessity and we all thank you for your understanding, and continued support.

It's important to note that this *only* applies to copies sold at Australian newsstands – our subscriber price remains unchanged, and that's always the best value way to get *APC*.

If you hadn't considered a subscription before, it's the cheapest way to get the print edition of *APC* – with a two year sub coming in at just $5.79 per issue, saving a very respectable 47% off the newsstand pice. It's also fantastically convenient, with each issue delivered to your door each month. *APC* is also available in digital editions that you can read on any Android device, iPhone, iPad or iPod Touch. They're even cheaper, at just $4.99 an issue.

Take a look at our subscription offers on pages 22 and 23 to see the options, and how to get it all rolling.

May I also humbly suggest that an *APC* subscription is a rather wonderful gift. Father's Day is upon us, and Christmas isn't very far off. Or, just treat yourself. A copy of *APC* every month is a great way to pass the time while things are as they are, and with sales of tech gear surging, our goal has always been to provide you with the best advice for what to buy, and how to get it running to perfection.

Once again, thank you for helping *APC* continue to deliver high quality PC and tech content each month, it is very much appreciated and as always we strive to give you a great magazine every time.

BEN MANSILL

"Thank you for helping APC continue to deliver high quality PC and tech content each month, it is very much appreciated."

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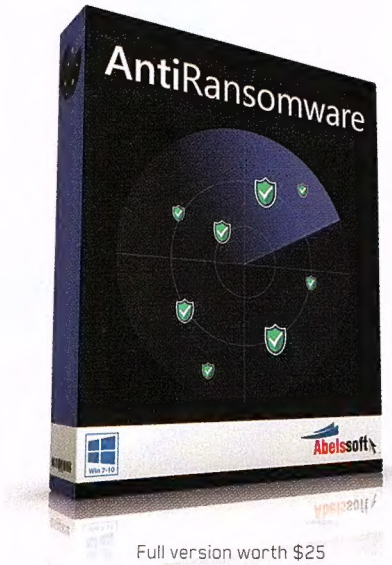

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The past few years have seen a huge amount of reports about blackmail Trojans, also known as Ransomware. You can fall victim to this threat just by opening an infected Word file, or even by surfing the internet. The worst part: So far there has been no effective protection. Once infected, the blackmail Trojan does not delete your private data, but encrypts it and holds you to ransom. In collaboration with specialists, Abelssoft developed AntiRansomware to offer an effective protection against Ransomware. The guard monitors all processes in the background and raises an alarm in case files on your PC are being encrypted.

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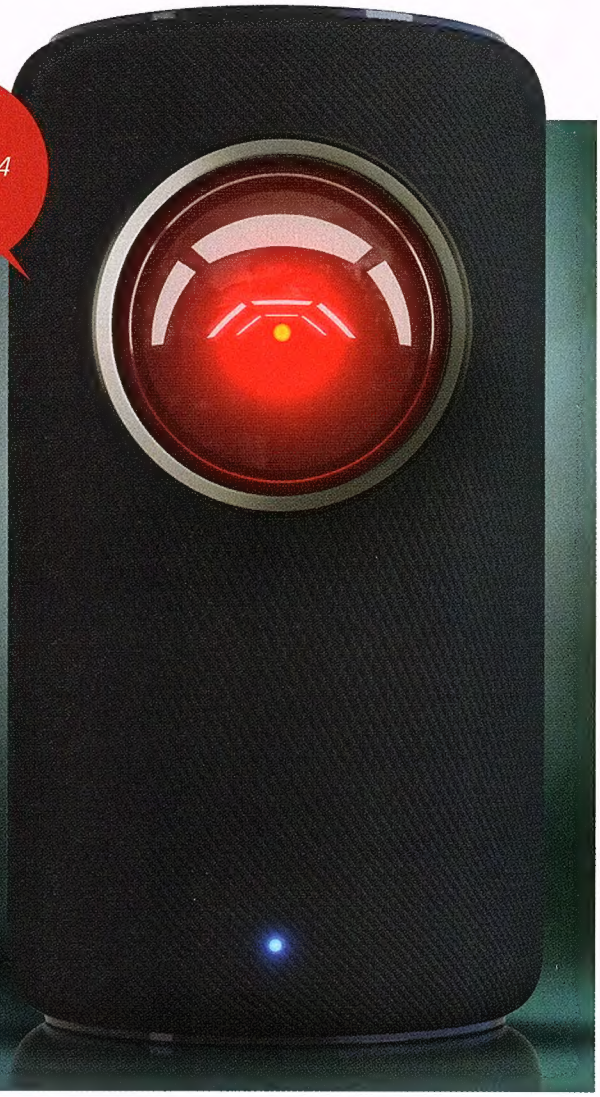

"Page 64 Dave"

Make your Smart Assistant *Smarter*

TOP TIPS FOR IMPROVING SIRI, GOOGLE AND ALEXA

Next-gen distros

Step right up! Jonni Bidwell is here to unveil the finest Linux distros around!

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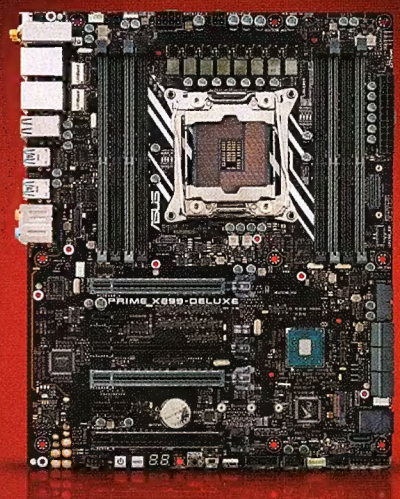

Anatomy of a motherboard

Gavin Bonshor breaks down just what makes your motherboard tick, in this primer on the computing world's most underlooked piece of tech

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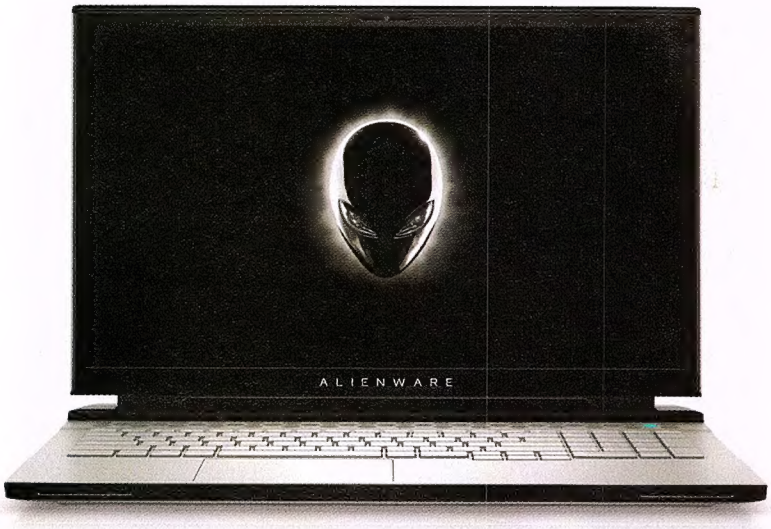

"the Nvidia RTX 2080 Super with Max-Q ploughed through games getting over 60fps averages on all benchmarks on '1080p ultra' settings"

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APC HOT PRODUCT
When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.
APC RECOMMENDS
You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

Inside *APC*

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

"APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible."

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

WLAN MESH

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TECHNOTES

ALL THE NEED-TO-KNOW TECH NEWS

Toshiba officially steps away from PC market

In a press release announcement Toshiba has come forward with news that the company is officially stepping away from the PC manufacturing market.

For decades, Toshiba has been a global competitor in the PC industry, going as far as introducing one of the first commercially available laptops in the 1980s. Over the last few years, however, Toshiba has been slowly removing assets - including major shares in its PC business.

In June of 2018, Toshiba relinquished over 80% of its PC subsidiary shares to Sharp, which rebranded Toshiba Client Solutions Co., Ltd under Dynabook. Since the purchase, Toshiba has still maintained ownership of the remaining 19.9%.

As of early August, Toshiba has officially sold that remaining stake, giving complete ownership of the PC business to Sharp under the Dynabook name. This move also classifies Dynabook as a fully-owned Sharp subsidiary.

Internet Explorer 11, legacy Edge losing Microsoft Support in 2021

After years of compatibility, Microsoft devs have decided to drop Internet Explorer 11 support for various Microsoft 365 applications, starting with Teams. This announcement was first posted on the Microsoft 365 blog.

The new changes go into effect on November 30th, 2020 beginning with Microsoft Teams. By August 17th, 2021 (a year to-the-date from the announcement) all of the remaining Microsoft 365 apps will no longer provide support for IE 11. Anyone using Internet Explorer 11 to connect to Microsoft 365 apps after the dates listed above will encounter serious degradation in performance. Some features may stop working entirely. While users can no longer use IE 11 for these apps and services, they can use Microsoft Edge's Internet Explorer mode.

BLUE TAKES ON RED AND GREEN

Intel Xe HPG gaming GPU: taking on AMD and Nvidia

Discrete Intel Xe HPG graphics cards will take on the best Nvidia and AMD have to offer in 2021.

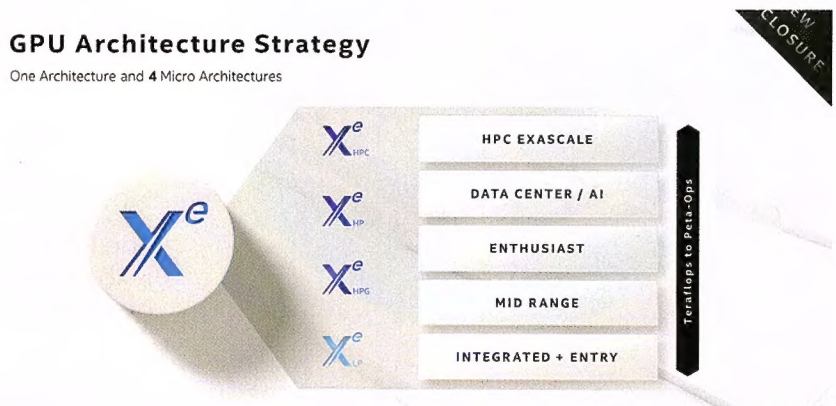
The reveal of the Intel Xe HPG during Intel's Architecture Day 2020 was part of a virtual firehose of information on a ton of upcoming products and technologies. One of the products we're most interested in seeing and testing is Intel's Xe Graphics.

Intel originally had plans for a single graphics architecture with two micro-architectures back in 2018. Two years later, the number of microarchitectures has doubled to four. Xe LP is for integrated graphics and entry-level solutions, Xe HP is for high-end compute and data centre workloads, and Xe HPC is basically Xe HP on steroids, targeting supercomputing exascale solutions. That leaves the fourth and final microarchitecture that Intel just announced: Intel Xe HPG, which will be the heart of the consumer card.

Given what we know of Xe HP, the bifurcation into two different parts makes a lot of sense. First, Xe HP of necessity has FP64 (64-bit floating point) support, along with tensor cores. These are common features in data centre compute, deep learning, and AI environments, but they're also extra bloat that's not needed for a gaming GPU. Second, Xe HP will use HBM2e memory.

Intel Xe HPG will address both of these items by removing the FP64 support (or at least trimming it way down) and by adopting GDDR6 memory. That's not the only change, however. Dumping FP64 (possibly tensor cores as well) and HBM gives Intel room to add in other features. Specifically, Intel confirmed that Xe HPG will support hardware ray tracing. That's a critical move, considering the AMD Big Navi / RDNA 2 and Nvidia RTX 3080 Ampere will both arrive in the next month or two with ray tracing, and in November the Sony PlayStation 5 and Microsoft Xbox Series X will launch with AMD GPUs that also support the feature. Trying to break into the GPU market with a product that lacks features the established players support wouldn't go over well.

The other major bombshell is that it plans to utilise a third party for fabrication of Xe HPG. That means it won't have to use up its limited 10nm SuperFin capacity making gaming GPUs, and it will perhaps join AMD and Nvidia by using TSMC to manufacture Xe HPG.



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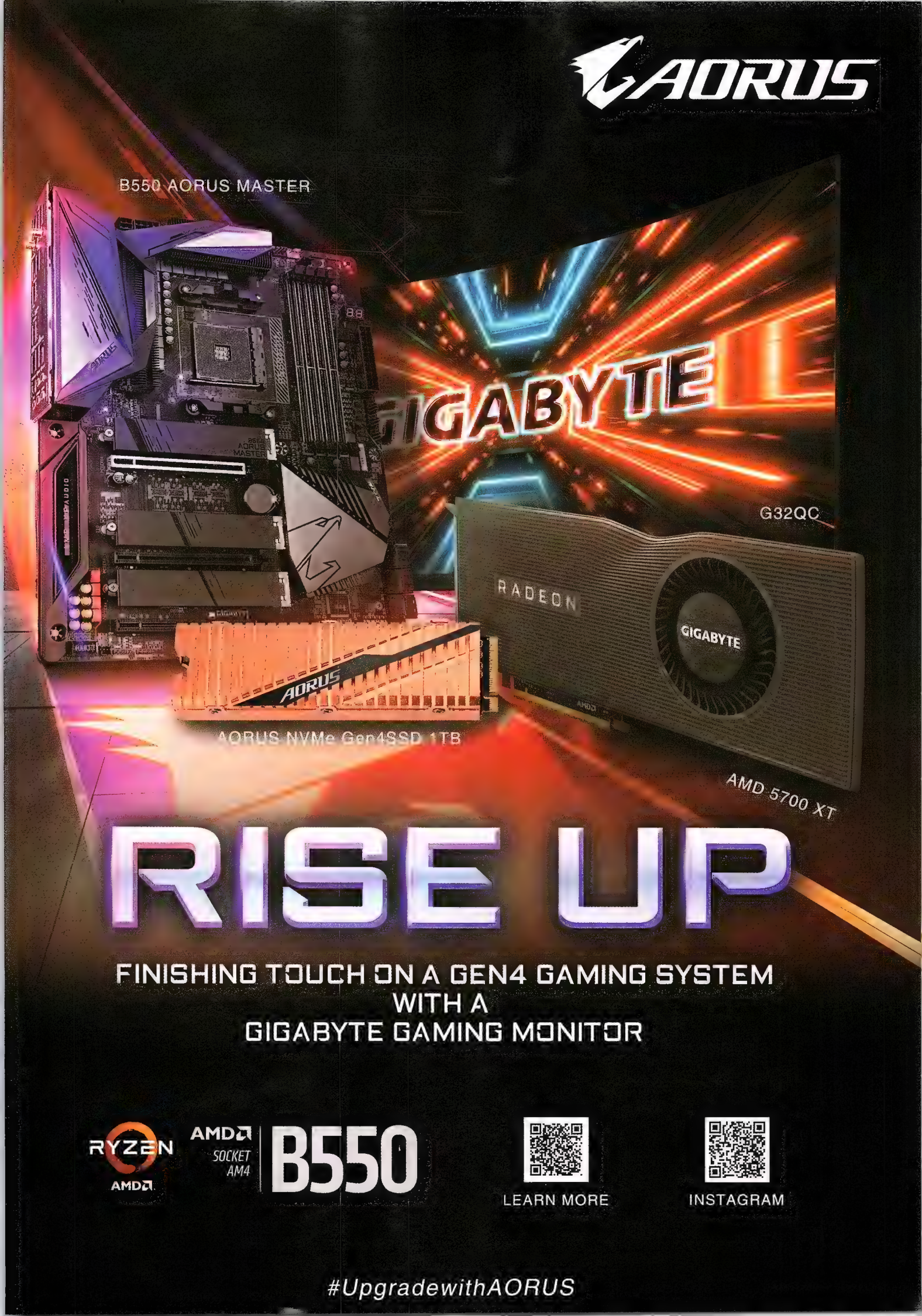

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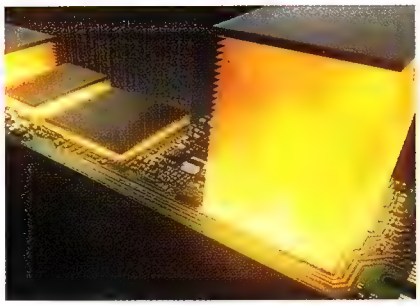


SK Hynix scores a world first: a consumer SSD with 128-layer NAND

Over the last few years, all of the major NAND makers have been in a race to build NAND memory with incredibly high layer counts, and now, these efforts are paying off for SK Hynix. The South Korean memory manufacturer is unleashing its Gold P31 SSDs onto the open consumer market, making SK Hynix the first to sell an SSD with 128-layer NAND.

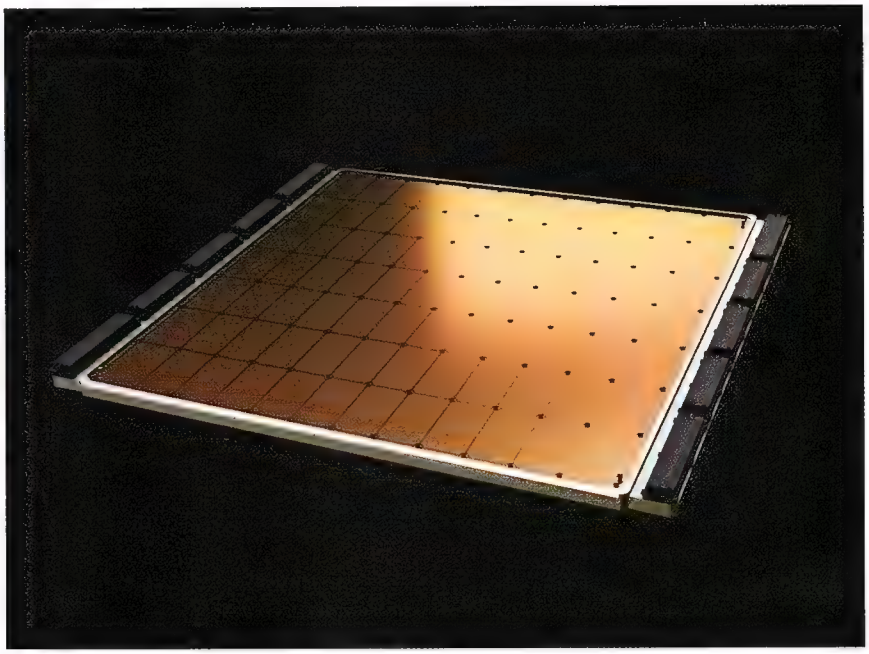
The Gold P31 SSDs come in the form of M.2 NVMe drives operating over the PCIe 3.0 interface, packing capacities of either 500GB or 1TB. Both of the drives feature read speeds of up to 3500 MB/s and writes of up to 3200MB/s, which is in-line with the best PCIe 3.0 based NVMe drives, saturating the PCI-Express bandwidth.

New Windows 10 update will provide more GPU options

In mid-August, the Windows 10 team released a preview of build 20190 to Windows Insiders via the Dev Channel. The new update comes with a change that gives users more control over GPU settings – especially those with multiple GPUs.

The first new change enables Windows to determine which is the power-saving GPU and which is a discrete graphics card. When starting an application, Windows 10 will decide what GPU an application requires. So if gaming, Windows 10 will use a discrete graphics card. For web browsing or productivity it will switch to a power saving GPU.

Another change is an option so users can assign a specific GPU to individual applications.



CANNOT BE REAL, BUT IS

Cerebras teases world's largest chip

2.6 trillion 7nm transistors and 850,000 cores.

The original Cerebras Wafer Scale Engine (WSE) is a marvel in truly every sense, but the company has now upped the ante. The original WSE brought an unbelievable 400,000 cores, 1.2 trillion 16nm transistors, 46,225 square millimetres of silicon, and 18 GB of on-chip memory, all in one chip that is as large as an entire wafer.

How do you top that? According to the Cerebras slide deck it shared at Hot Chips 2020, you transition to TSMC's 7nm process, which allows a mind-bending 850,000 cores powered by 2.6 trillion processors – all in a single chip that's the size of an entire wafer. The company says it already has the massive chips up and running in its labs.

The current Cerebras Wafer Scale Engine (WSE) sidesteps the reticle limitations of modern chip manufacturing, which limit the size of a single monolithic processor die, to create the wafer-sized processor. The company accomplishes this feat by stitching together the dies on the wafer with a communication fabric, thus allowing it to work as one large cohesive unit.

The end result is 55.9 times larger than the world's largest GPU (the new Nvidia A100 measures 826mm2 with 54.2 billion transistors).

HOW TO MAKE EVERYONE HATE YOU

Oculus VR headsets will soon require a Facebook login

Oculus accounts will start disappearing soon.

Oculus is finally taking the fear we all had when Facebook bought it and making it a reality. This October, the company will start ending support for Oculus accounts and replacing them with Facebook accounts. In a post on its website, Oculus announced that starting this October, new Oculus users will have to log into their Oculus HMDs with a Facebook account.

Those with an existing Oculus accounts have two years to merge it with a Facebook account. Beginning in 2023, Oculus will completely end support for Oculus accounts. At that point, if you don't merge your account with a Facebook account, Oculus can't promise full functionality for your device.

The company claims that the change is due to the ease-of-use presented by a single log-in, as well as upcoming Social VR features, like Facebook Horizon.

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ASUS

TECH BRIEF

AMD patents hybrid x86 technology: low-power cores set to return

AMD gets a patent for Arm's Big.Little-like technology.

AMD has been granted a patent for heterogeneous microprocessors featuring two types of general-purpose cores. The technology resembles Arm's famous Big.Little architecture and could be used for CPUs aimed at mobile and low-power devices.

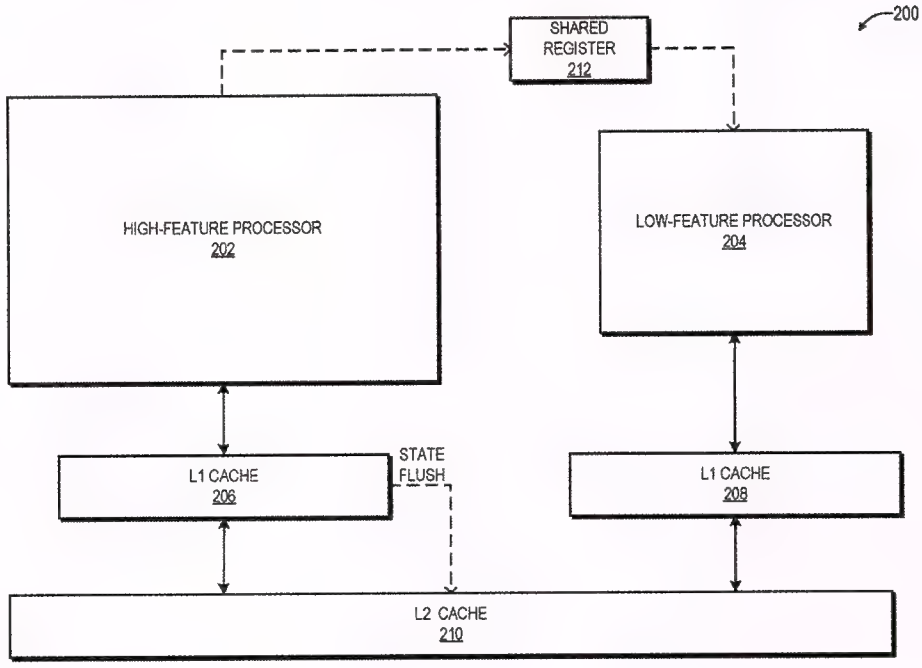
The patent outlines a microprocessor featuring two types of general-purpose cores running two different subsets of the same instruction set architecture (ISA). The first type of cores is set to support a larger subset of the ISA and feature high performance, whereas the second type of simplified cores is configured to consume less power. Different types of cores can share memory locations as well as cache.

The technology enables AMD to build power-efficient processors based on x86, Arm, and other architectures (but not all at the same time) and featuring two classes of general-purpose cores.

One important capability that AMD describes in its patents is dynamic shift of a thread from one core to another (assuming that all features are supported) if a high-performance core is under-utilised or low-power core is over-utilised. The method might give CPU some more freedom to balance the load of its cores with little or no intervention from an operating system, though it remains to be seen how this will work as load balancing of even homogeneous multi-core CPUs on OS side has been a performance-defining factor in the recent years.

The patent number 10,698,472 was filed on October 27, 2017, after AMD started to make and sell microprocessors running on Zen microarchitecture and years after it dropped further development of its 'Cats' low-power cores based on the codenamed Jaguar and Puma microarchitectures. Therefore, it is likely that AMD is considering to introduce Zen derivatives or a brand-new microarchitecture for low-power/low-cost applications.

Patent hunting is not exactly a rewarding business since companies that spend billions of dollars on research and development file for hundreds of patents every year and far not all of the patents get implemented in real products. Microprocessors featuring different general-purpose cores have become ubiquitous in smartphones and are likely to become pervasive in mobile PCs as well. Meanwhile, it is not guaranteed that we are going to see hybrid processors like Intel's Lakefield from AMD in the foreseeable future.



"The technology enables AMD to build power-efficient processors based on x86, Arm, and other architectures (but not all at the same time) and featuring two classes of general-purpose cores."

The abstract of the patent reads as follows:

"A heterogeneous processor system includes a first processor implementing an instruction set architecture (ISA) including a set of ISA features and configured to support a first subset of the set of ISA features. The heterogeneous processor system also includes a second processor implementing the ISA including the set of ISA features and configured to support a second subset of the set of ISA features, wherein the first subset and the second subset of the set of ISA features are different from each other. When the first subset includes an entirety of the set of ISA features, the lower-feature second processor is configured to execute an instruction thread by consuming less power and with lower performance than the first processor." ■

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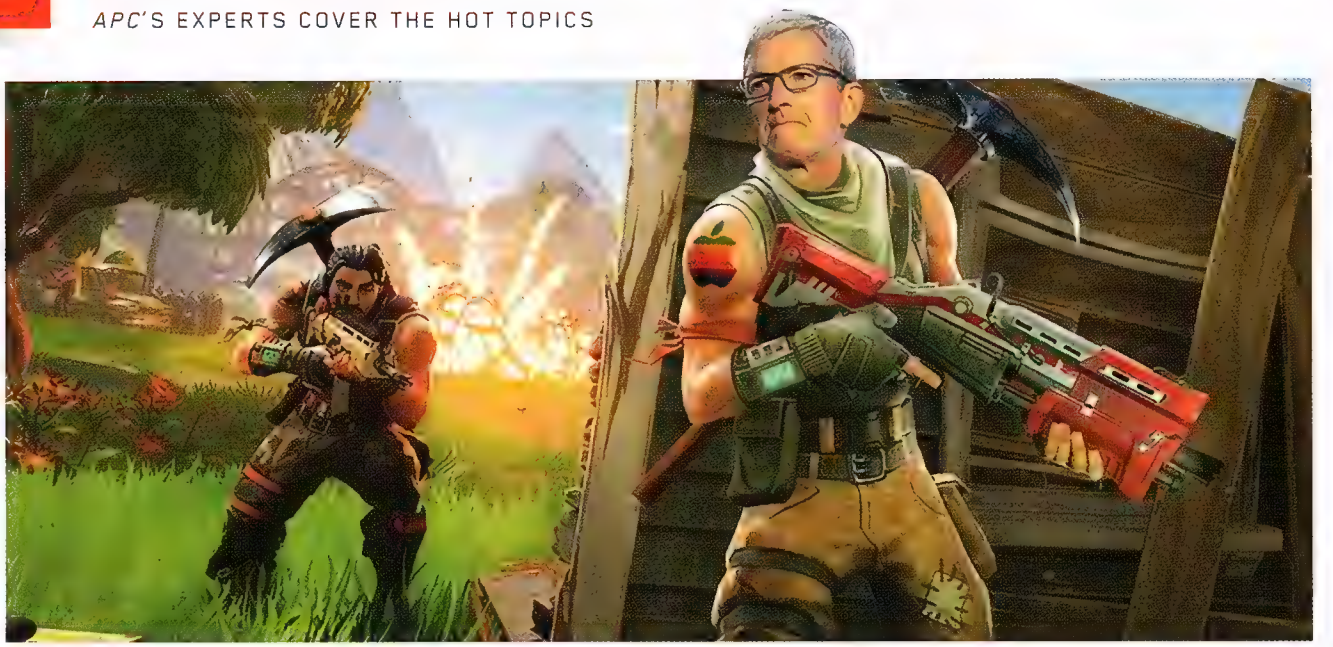


END USER

Epic goes gloves off with Apple and Google

The fight between the *Fortnite* creator and two tech giants will be fought by its fans, writes Shaun Prescott.

Everyone knows what *Fortnite* is, but in case you don't, it's a massively popular free-to-play battle royale with over 250 million registered users (as of April 2019) and a current concurrent player record of 12.3 million (as of April 2020). Creator Epic Games wasn't doing too poorly before the game's massive success – it operates the widely used Unreal game engine, among other things – but it's fair to say that the partially Tencent-owned company is sitting pretty right now.

As a result, it's throwing its weight around. In August it attempted to defy Apple and Google's 30 percent cut from *Fortnite* in-game transactions, by giving users the option to pay the usual way (via both App Store's usual payment infrastructure) or with a direct payment to Epic. It was a matter of hours before Apple removed *Fortnite* from its shopfront. Google followed suit shortly after.

Epic shot back with a lawsuit, and an attempt to win *Fortnite*'s millions of players to its cause with an in-game video. But a week later Apple upped the ante: the company said that due to Epic's violation of its License Agreement, it would terminate Epic's developer accounts, as well as its access to Apple development tools. This is a much bigger deal than it immediately sounds, as it effectively means that any developer using Unreal Engine to develop games for iOS or Mac can no longer do so.

For once, Epic was driven to the defensive: it sought an injunction and filed a new lawsuit to attempt to quash Apple's policy threat. At the time of writing, it's unclear how this will unfold, but Epic is taking it very seriously: "This is quintessential irreparable harm," the company's lawsuit read.

Anyway, why should Epic fight the 30 percent cut collected by Apple (and Google)? It's a good question with several answers. I daresay that Epic would simply love to have that money for itself, but that's not the way it's framing the battle. Epic CEO Tim Sweeney said it was about the "basic freedoms of all consumers and developers".

"At the most basic level, we're fighting for the freedom of people who bought smartphones to install apps from sources of their choosing, the freedom for creators of apps to distribute them as they choose, and the freedom of both groups to do business directly," he wrote.

It's a good point: Apple is worth trillions of dollars (which dwarves the mere billions of Epic). When Epic accuses Apple in its lawsuit of using monopolistic practices, it's hard to argue: iOS is a vital platform for any smartphone software developer, and there is currently no way to operate software on it unless you're pouring cash straight into Apple's coffers. This is quite unlike, for example, the PC: Microsoft may appear keen to encourage Windows users to stick to the Microsoft Store, and to stick to Edge… but you don't have to. To a lesser degree this is kind of the same for Google's Android platform – indeed, Epic originally encouraged Android users to download *Fortnite* via a web browser, before finally caving in in April and launching a dedicated Android app.

Will Epic win? Its techniques have worked in the past: it encouraged Sony to begin dismantling its anti-crossplay policy on PS4 by just going ahead and activating it in *Fortnite*. It knew that fan outcry would win the day. Will this prove the case in the Epic vs Apple debacle? One thing's for sure: Epic is counting on its *Fortnite* userbase to agitate. ■

SHAUN PRESCOTT
Author, PC gamer and passionate technology observer, Shaun covers trending tech topics for *APC*.

RANDOM ACCESS

How important are CPUs for gaming?

What are the important things to consider when buying a CPU for gaming, and should you go red or blue?

While the GPU takes a lot of the limelight for gaming performance, your CPU actually plays a critical role in the performance of modern games too. It may not actually render anything, but it is responsible for lining up what will be shown on screen and in games with a lot of complicated computational processes (like when you have lots of independently moving soldiers) the CPU is doing the heavy lifting in working out where all those bits need to be.

There's two important factors in how good a CPU will be for gaming: clock speed and the number of cores. Depending on the specific game you are running one or both of these factors could be a critical component. As a minimum, modern games require a quad-core CPU. This is primarily because games have to be optimised for use with particular kinds of hardware and so most developers will aim for a balance that allows the game to be run well on the broadest range of architecture. Quad-core is really the minimum you can get away with on modern games to do them justice.

Many developers however, are keen to show off their games capabilities and will build them with performance that scales alongside CPU power. *Battlefield V*, for example, will run 32.9% better on a hexa-core chip than a quad-core one, and if you have an octa-core CPU at the same clock speed it'll offer 40.5% better framerates using an Nividia RTX 2080 and 16GB RAM configuration. This is 57fps and 79fps better respectively using 1080p settings, so it can make a noticeable difference to your games, especially at high framerates.

There isn't too much information on which games scale better with more cores, but it's generally a safe bet to say that strategy games like *Total War* titles utilise multi-threading and will perform better, but *Rainbow Six Siege*, *Assassin's Creed Odyssey*, *Hitman 2*, *GTA 5*, and *The Witcher 3*, are all known to scale to varying degrees with higher CPU core counts up to a peak of eight. We couldn't find any games that benefited more than around a few percent from having a total of 10 or 12 cores running. This may change as developers begin to design games for higher core-count CPUs, but for now there's not much benefit to gaming performance.

"We couldn't find any games that benefited more than around a few percent from having a total of 10 or 12 cores running."

JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

While the titles we've looked at above are designed in a way to utilise multi-core, multi-threaded CPUs, it's fair to say that the vast majority of games still rely primarily on a single optimised thread to do the majority of in-game processing, while palming off smaller tasks to at most a few other CPU cores/threads. This means that a higher clock speed will have a greater impact on the largest number of games than overall core count. It is this simple fact that allows Intel to keep a competitive edge against AMD when it comes to gaming (even though AMD convincingly outperforms Intel in general processing tasks for similarly priced CPUs). This means that Intel's latest i7's and i9's are around 9% faster than AMD's when using an Nvidia graphics card (the difference is negligible when using a Radeon GPU), even though they offer 20-25% less raw computing performance generally.

It's also worth remembering that CPU performance is more likely to affect games running at high framerates (100+ fps) than high resolutions, so the best CPU for you will really depend on the types of games you prefer to play. ■

TWO BITS

Fast RAM is more affordable than ever

Does it provide a real advantage, though?

If you're looking into building a new system, of course you'll need some RAM. The DDR4 standard is now well and truly mature and speeds are faster than ever. While the base speed for DDR4 is 2133MHz, that speed is obsolete. Even 2400 and 2666MHz kits aren't much cheaper than a now commonplace 3200MHz kit. That means 3200MHz is effectively the current baseline, and there's an argument that 3600MHz is becoming the sweet spot in 2020. We won't focus on timings here other than to say that lower timings are advantageous, though comparing the performance of something like DDR4-3200 C14 to DDR4-3600 C16 is highly application-specific.

So, is it worth going for RAM at 4000MHz or even higher? Unless you're a competitive overclocker, the answer is no. Intel CPUs tend not to benefit a whole lot from very fast RAM. Part of this is due to the inherent lower latency of their single die designs. This is thought to be the reason for Intel's strong gaming performance vs AMD. Also, if you're planning a B460 build, you'll be limited to a maximum of 2666MHz or 2933MHz if you use an i7 or i9 CPU. On Z series chipsets, 4000MHz and faster can introduce compatibility issues, where XMP may not work without some additional tweaking.

If you're building a system with a higher-end Ryzen 3000 series processor, then you'll strongly want to consider a 3600MHz kit. This is because the memory clock on these systems is tied to the Infinity Fabric clock, which is the interconnect that AMD uses for cross-die communication. The Infinity Fabric tops out at 1800MHz or a bit higher. Bearing in mind that DDR means Double Data Rate, this makes 3600MHz RAM run 1:1 with the Infinity Fabric. AMD systems can run a lot higher than 3600MHz RAM, but running the Infinity Fabric slower than the RAM clock incurs a latency penalty, which cannot be overcome unless you are running very high speed RAM. Grab yourself a good 3600MHz kit for your AMD system. Set it and forget it. Also note that faster RAM benefits the graphics performance of AMD's APUs. You wouldn't want to go overboard with expensive RAM on such a system, but if you're gaming on a 3200G or 3400G, an extra $20 or so spent on a faster RAM kit will deliver higher FPS.

Very fast kits above 4000MHz still carry a fairly hefty price premium which makes their price/performance highly questionable. Additionally, if you're running high resolutions and graphics settings, you really won't see much benefit with very fast RAM. You might get a bit of a boost with higher minimums, but that's about it. Where you'll see more of a benefit is with lower graphics settings or games that you play at very high FPS. Even then it depends on the game itself.

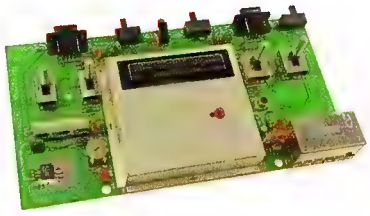
In summary, a good 3200MHz or 3600MHz kit is sufficient for most use cases. Faster memory can be beneficial in some applications, so a bit of research into the apps you commonly use could prove to be an eye opener. Your apps or game may surprisingly love the extra bandwidth. ■

"So, is it worth going for RAM at 4000MHz or even higher? Unless you're a competitive overclocker, the answer is no."

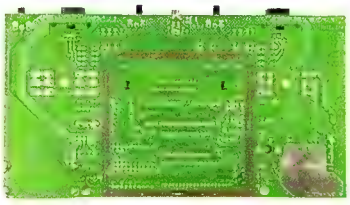
CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked acoss the industry in many areas as a product and technology expert.

HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND



The motherboard of the 2600 is dominated by an ominous metal box, likely the EMI shield covering the ICs.



This model was revision 13. How lucky!

Atari 2600

How it used to be done.

Originally called the Video Computer System (VCS) until 1983, the Atari 2600 was released in 1977. The system was originally released with all six switches on the front of the console, but the console was redesigned in 1980 with only four of the switches on the front, and the other two on the back. The console featured here is a post-1980 model.

Major tech specs

- 1.19MHz eight-bit processor
- 128 bytes RAM
- 192 x 160 pixel resolution
- 128 colors, with max four colors per line
  two-channel mono sound

Key findings

- Video game consoles these days may not have a sense of home decor, but some computer companies still believe in the aesthetics of wood paneling. As soon as users figured out that the Atari 2600 could play more games than just Pong, the 2600 became massively successful, selling 1 million units in 1979.
- Instead of following the trend of building a limited number of games into the system, the Atari 2600 uses removable cartridges to store games like *Space Invaders*, *Pac-Man* and *Pitfall*. Each player can select the difficulty of the game they're playing by simply flipping a switch from "A" to "B". Which one was harder is anyone's guess.
- There are four screws holding the upper and lower case together. These screws in the back are at an odd angle: Almost 30 degrees off of vertical. Strange. With a design that is unseen in just about any other electronic device, the motherboard is propped up and sits at an angle of 30 degrees inside the Atari. Now those case screws make sense! And finally, cables that are not soldered to the board! The RCA cable is easily removed.
- The motherboard easily lifts out. The only things securing it down were the angled screws we removed from the outer case. The case of the 2600 is 2.6 times larger than the motherboard. The motherboard is dominated by an ominous metal box, likely the EMI shield. A few short twists with pliers and the shield lifts free; Atari gets a +1 on repairability for not soldering the shield to the motherboard. The back of the Atari 2600 motherboard has nothing interesting on it, except a great appreciation for through-hole soldering and hand-drawn circuits.
- The Atari 2600 stores games in read-only memory chips housed in external cartridges. This allows for a potentially infinite number of playable games for the console. Atari's custom chip, the Television Interface Adapter (TIA) is the moneymaker of the 2600, as it enables multiple colours, increased graphic capabilities, and sound. Because memory was so expensive during the 2600's design, the video processor has no external RAM. As a result the CPU must send video data to the TIA one line of video at a time.
- We give the Atari 2600 a big plus for repairability. Every component is attached via through-hole solder, so replacing a burnt-out resistor or IC is quite feasible. However, parts are now almost impossible to get hold of. ■

The Atari 2600, with AC adapter and iconic joystick controller. Does the 2600 have a hardwood finish? You are correct!

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Brydge Surface Accessories

Bridging the gaps in Microsoft's Surface accessory range.

Microsoft actually makes plenty of awesome accessories, but it doesn't cover everything and Brydge is very good at filling the gaps that Microsoft misses. The most obvious is the new W-Touch and Brydge W-Type for the Surface Studio, which is the first stand-alone trackpad we've seen built for a Windows PC. The company also has a new version of its trusty Surface Pro Brydge 12.3 Pro+ keyboard that turns the device into a clamshell laptop. If you love the Surface Pro, but sometimes wish you could use it on your lap, then the Brydge keyboard is a neat accessory.

From $649 | samsung.com/au

Galaxy Watch3

Samsung's got a new watchie.

We're not totally sure what happened to the Galaxy Watch 2, or the space before the 3 in the name, for that matter, but who cares – the Galaxy Watch3 (read Watch'E') is here now. The new Watch3 is slimmer and lighter than the original and the rotating bezel returns after a brief hiatus on the Galaxy Watch Active. The larger model also has a slightly bigger screen than its predecessor and Bluetooth 5 connectivity, which will be great for headphone connection stability. Unfortunately the Watch3 uses the same processor as the Galaxy Watch and early reports suggest battery life isn't quite as good. That said it's still one of the best smartwatches you can get your hands on.

$319 | samsung.com/au

Samsung Galaxy Buds Live

The first true-wireless buds to out sci-fi the AirPods.

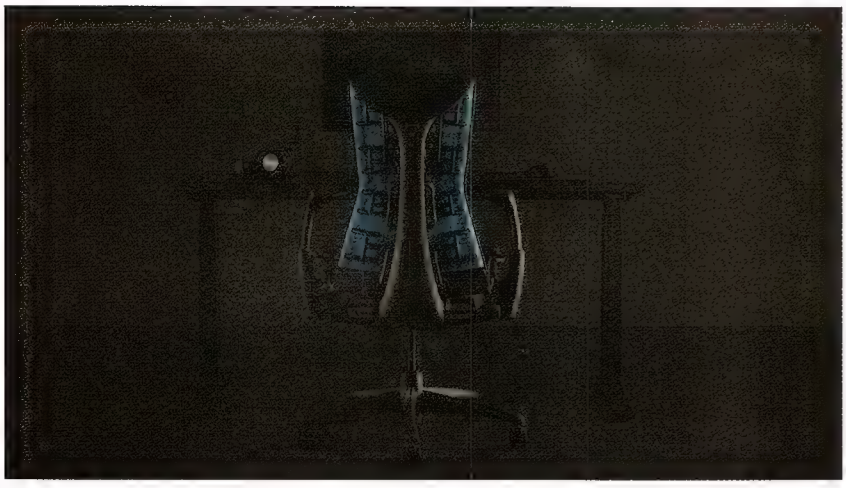
True-wireless earbuds are a competitive space, but we still haven't seen any breakout successes (apart from maybe the AirPods). Samsung's going to have a crack at it, drawing on its AKG tech pedigree to power the 12mm drivers in the new Galaxy Buds Live. These buds have a new jelly bean shaped tip-less design made out of reflective case materials that make it look like you've got a bubble of molten metal in your ear. Bluetooth 5.0 means you can connect and easily switch between audio sources and the 6/21 hour earbud case battery life with voice assistant tech and ANC makes it a pretty compelling offering.

$2,899 | irobot.com.au

Roomba S9+

The new top bot for beating chores.

iRobot has made a name for itself in the premium auto cleaning space, but it seems to have gone above and beyond this year with a new, even more luxxy Roomba S9+ robovac. The most exciting new feature is a bin base that'll hold around 30 full-loads of the S9+, which means you won't have to empty it after each clean anymore. It's also got a new set of brushes that get right alongside edges and deeper into corners without losing efficiency and if you really want to splurge it is designed to work alongside the company's Brava m6 robot mop to vacuum and wipe down your floor.

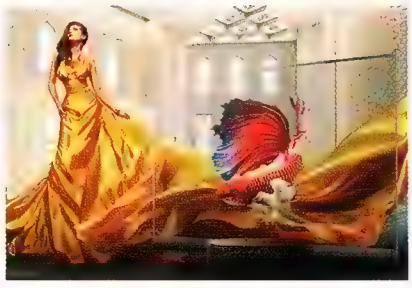


US $1,495 | store.hermanmiller.com

Herman Miller x Logitech G Embody Gaming Chair

Work meets play in this new gaming chair.

Generally you're forced to choose between a comfy gaming chair and a nice looking professional work chair, but what if you could have both? Logitech have partnered with Herman Miller, the furniture design company attributed with the creation of the office cubicle and Aeron chair, to make a chair that's ready for work and play. Featuring copper-fused cooling foam, customisable lumbar support and all-round adjustability, this is a full featured gaming chair that'll keep you in peak performance for longer... and will look professional while doing so. It even comes with wheels that can be optimised for either floorboards or carpet.



Around $10,000 | mi.com/global

Xiaomi Mi TV LUX Transparent Edition

The first mass-market see-through OLED TV.

Chinese tech manufacturer Xiaomi has unveiled one of the first fully transparent TV sized displays as part of its 10th Anniversary event. The display hides most of the processing components in the base and uses transparent OLED pixels to display images so that you can see through the panel when they're not engaged. While we couldn't find any brightness specs (which will be the key factor in how amazing this is in person), it does offer 10-bit colour processing and an 120Hz refresh rate, so it's not shabby on other TV tech.

"If you are one of the few left in the shrinking pond of users needing something bigger than a phone, but more portable than a 1.2kg laptop then the iPad Pro is still a standout choice."

From $1,329 | apple.com/au

Apple iPad Pro

The iPad Pro is a truly amazing bit of technology, but is it something you need, or just something you really want.

Apple has always been a company that carves its own niches from competitive consumer segments and the iPad Pro is one of the clearest examples of that. The 2020 iPad Pro is sticking to its guns by resisting the trend to convert to a full detachable 2-in-1 laptop equivalent, despite being more than powerful enough to do so – but, at the same time, the new 2020 model is also starting to make some concessions. Most noticeable of these is the new Magic Keyboard which for the first time includes a trackpad.

Since the iPadOS experience is so tailored to the touchscreen interface even the apps that incorporated the new trackpad functionality at launch can't really use them in the same capacity as their MacOS equivalent software will. This gives rise to a feeling that the iPad Pro hardware has outgrown its operating system, since it's easily capable of running fully-fledged MacOS apps. See, the iPad Pro outpaces the highest specced Surface Pro 7 by close to 9% in Geekbench 5 multi-platform benchmarks, so it's undoubtedly a laptop equivalent in terms of power, but open up any of Adobe's iPad applications and you'll get the same compact experience you get on a regular iPad or iPhone. It is a little disappointing from a device that costs as much as a capable 1080p gaming laptop to feel constrained by such streamlined and lightweight software.

If you are one of the few left in the shrinking pond of users needing something bigger than a phone, but more portable than a 1.2kg laptop then the iPad Pro is still a standout choice. You can get it in an 11-inch form factor or a 12.9-inch variation, but other than size, weight and screen pixel count, all the internals are the same across the two form factors. Backing up the powerful octa-core A12Z CPU is a sufficient (but unspecified) allocation of RAM and a good range of connectivity options including Wi-Fi 6, Bluetooth 5 and USB-C interfaces. The Apple Pencil continues to offer market leading responsiveness and the suite of software that accommodates it is rich and allows you a lot of creative freedom.

If you're a photographer, vlogger or cinematographer that needs something to process your work when you're out and about then the iPad Pro is capable of filling the space of a laptop in many of these types of workflow. It's also a great accompaniment to a proper creative workstation for anyone who wants the freedom to work without physical boundaries. It's even got LTE connectivity to make sure you're always connected to your cloud and Apple is expanding into new spaces by including things like a LiDAR scanner and dual rear camera array that allows for full scale room scanning – a powerful tool for animators or VR devs.

There are a number of professional use cases where the iPad Pro offers unparalleled functionality and if you have the cash to drop on it then you aren't likely to be disappointed, but we can't help but think that the iPad Pro really only makes sense for a select group of creative professionals who know in advance exactly how they're going to use it.

JOEL BURGESS

SPECS

iPadOS 14+; 11-inch or 12-inch 264ppi Multi-touch HDR 600 nit display (DCI-P3); A12Z Bionic SoC with Neural Engine AI processor; 12MP Wide f/1.8 and 10MP Ultra-wide f/2.4 rear cameras; 7MP TrueDepth camera 1080p webcam; WiFi 6; Bluetooth 5.0; LTE (Apple Nano-sim or eSIM); 28.65Wh battery (9h LTE web surfing lifespan).

A supremely powerful tablet that excels in select creative spaces, but may need to pivot to be broadly appealing in the future.

★★★★☆

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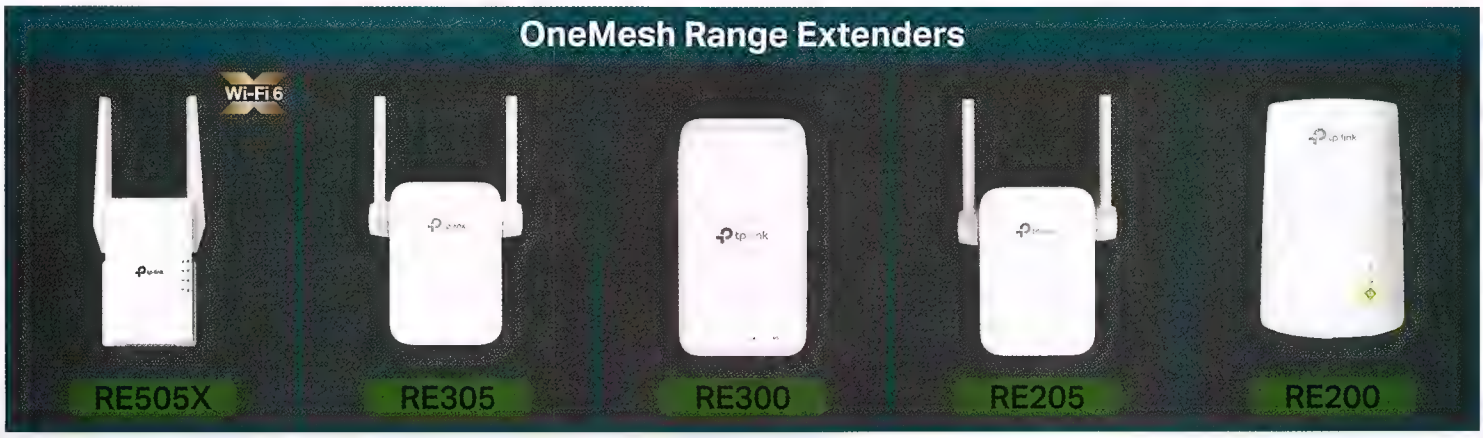
- Wi-Fi Dead Zone Killer

OneMesh Range Extenders



For a full list of OneMesh Compatible routers go to

www.tp-link.com/au/onemesh/compatibility/

$2,899 | lenovo.com/au/en

Lenovo Legion 5i

Lenovo is hoping to amass an army of buyers for its new budget gaming build, but is the Legion 5i a convincing call to arms?

Lenovo is pitching its new Legion 5i 15-incher as the everyman's gaming laptop, balancing price and performance to hit the most broadly popular configuration for those on an average budget.

Price is a critical factor at this end of the market and the Legion 5i starts at $1,599 for a laptop with an Intel Core i5-10300H CPU, 8GB of RAM, a GTX 1650 GPU, 256GB M.2 SSD and a 120Hz FHD screen – a pretty sweet deal for something that is capable of entry-level 1080p gaming. The model we were given to test had an Intel Core i7-10750H CPU, 16GB of RAM and an Nvidia GeForce GTX 1660 Ti, which is a good step-up arrangement if you're trying to get the best performance at an entry level budget. This configuration also bundles in a 512GB M.2 SSD and the same 15.6-Inch 1080p 120Hz screen for a total cost of $2,399. This is a pretty common configuration offered by devices like Dell's G5 15 and MSI's GF63 Thin, at very similar price points… so there's not much variance in value at this end of the market. This means vendors have to go that little bit further to get customers over the line and the Legion 5i has a few tricks up its sleeve to do just that.

In an attempt to squeeze a little more life out of the 60W battery, the Legion 5i is one of the first laptops we've seen to utilise Nvidia's Advanced Optimus adaptive screen technology. Advanced Optimus saves on power consumption by switching the screen input from the discrete graphics card to the integrated GPU when it's not in use, allowing it to spin down entirely. Unfortunately the automatic switching doesn't work seamlessly just yet, with input glitches inhibiting a number of our benchmarks before we discovered what was causing the issue. The device managed to last one hour and 42 minutes in PCMark8's Home Battery life benchmark and 2two hours and 42 minutes in 1080p movie playback when the GPU was constantly engaged, but the latter ended up at closer to four hours when Advanced Optimus was engaged. It is worth noting that the system also seems to cut the overall brightness when the GPU is off, so your mileage will vary with additional battery life.

SPECS
Windows 10 Pro 64-bit; Intel Core i7-10750H CPU, 16GB RAM; Nvidia GeForce GTX 1660 Ti; 512GB M.2 PCIe SSD; 60Wh Battery (2:42 hour 1080p movie playback); 36.3x26x2.6cm; 2.5kg.

The other major perk is the 120Hz screen on the least expensive models, which will mean you can play lightweight online shooters at over 60fps for a more competitive experience. This isn't some magical new screen so there are some caveats including a 250 nit brightness and 45% sRGB colour gamut, which means the display is a little dull, but this will be a sacrifice many are willing to make to get a faster refresh rate on a budget. If you do need a more standard IPS panel you can pay $50 for a 60Hz 100% sRGB panel, or soup it up to a 500 nit, Dolby Vision, 240Hz, <1ms response time display with VESA DisplayHDR 400 certification for $500 extra.

If you look at something like Asus's TUF A15 you can get similar or better performance for around $400 less, so while the i5 is a decent device, there are better deals around.

JOEL BURGESS

Indicates best result

	Lenovo Legion 5i	Asus TUF Gaming A15
PCMark 8 - Home accelerated	4,107	4,793
PCMark 8 - Home Battery	01:42	03:15
HWBot x265 - 1080p	35.695	55.733
Cinebench R20 - multi-threaded CPU	3,091	4,366
3DMark Time Spy (score)	4,075	6,317
Total War: Warhammer II - Ultra 1080p (fps Av.)	37.3	62.3
CrystalDiskMark Read (MB/s)	3,502	1,798
CrystalDiskMark Write (MB/s)	2,979	1,715

A decent range of entry level gaming laptops with some innovative perks at affordable prices.

★★★☆☆

$6,399 | dell.com/en-au

Alienware m15 R3

Dell's well-established 15-inch gaming rig gets Intel's 10th Gen CPUs.

The Alienware m15 laptops have been a staple of Dell's gaming laptop range for years now and as per the company's business model you can get this new 15-inch rig with just about every CPU and GPU combo you could want. At the lower-end this includes a new 10th Generation Intel Core i7-10750H CPU, an Nvidia GTX 1660 Ti GPU, 16GB of RAM and a tiny 256GB PCIe SSD for $3,199. If however, you're after a top-tier pro setup then you can drop $6,399 on a unit with a Core i9-10980HK CPU, a Nvidia RTX 2080 Super GPU, 32GB of RAM and a 1TB PCIe SSD. The entire range come with a base FullHD 144Hz (7ms response time) IPS panel with G-Sync that can be swapped out at no cost for a crazy-fast 300Hz (3ms) 1080p display without G-Sync; or upgraded to a 60Hz OLED 4K screen with 400nit brightness and a HDR DCI-P3 colour gamut for an extra $500.

The unit that Dell sent us had all the top specs, which is pretty steep at $6,399, even in the premium laptop space. You can't get anything with this CPU/GPU combo for under $5K, but there's a number of comparable offerings for under six grand, so the m15 R3 is a little overpriced, on the whole.

Alienware's 2020 m15 R3 has reintroduced the T-shaped base design after a brief hiatus on its last model – so the bottom half of the unit once again protrudes out behind the screen hinge for heat vents that don't have to fire directly onto the display. This design is complimented by a powdery matte white or soft grey top that's subtly embossed with the number '15' in a sleek sci-fi font. This elegant design is matched with a nicely weighted keyboard with deep travel and a silky smooth trackpad.

You need some serious thermal management to keep an overclockable 8-core CPU in check, but Alienware has been running Core i9 CPUs in laptops for a few iterations now and seems to have a cooling system up to the task. We generally saw about a 10% bump in CPU performance in multi-threaded CPU benchmarks over the Intel Core i9-9980HK CPU, but the single-core performance fluctuated too much to offer any obvious improvement. In comparison to last year's Alienware m15 running a Core i7-8750H CPU and 16GB of RAM you'll see between 20% and 35% overall computing performance.

Unsurprisingly the Nvidia RTX 2080 Super with Max-Q ploughed through games getting over 60fps averages on all benchmarks on '1080p ultra' settings. You'll still have to optimise the graphics on the latest games to make the most of the new 300Hz monitor, but it's not like there's a more powerful GPU you could upgrade to yet.

Battery life was pretty woeful at just one hour and 37 minutes in PCMark 8 Home, and this didn't improve much in 1080p movie playback, lasting just two hours and three minutes, but this is all you can really hope for from an 86Wh battery running such powerful components.

JOEL BURGESS

All up the m15 R3 is an awesome looking machine that ticks all the boxes of a premium gaming notebook, but there are equivalent Aorus and MSI offerings that are much better value.

★★★★☆

SPECS

Windows 10 Home 64-bit; 15.6-inch 144Hz (7ms) 300nit IPS display @1920 x 1080p resolution; Intel Core i9-10980HK CPU; Nvidia RTX 2080 Super (Max-Q) GPU; 32GB RAM; Killer WiFi 6 AX1650i; 86Wh battery (1h37m PCMark 8 Home); 276 x 360 x 20.5mm; 2.5kg.

Indicates best result

	Alienware m15 R3	Aorus 17
PCMark 8 - Home (score)	5,297	4,665
GeekBench 4 - Single Core	5,793	5,818
Cinebench R20 - multi-threaded CPU	3,461	3,091
3DMark Time Spy (score)	7,896	9,045
The Division 2 - Ultra 1080p (fps Av.)	89	91
Total War: Warhammer II - Ultra 1080p (fps Av.)	80.7	89.3
CrystalDiskMark Read (MB/s)	3,329.9	2,919.2
CrystalDiskMark Write (MB/s)	2,451.4	1,533.4

"We tested the Aurora R9 with 16GB of 2666MHz DDR4 RAM and a Nvidia GeForce RTX 2070 Super, for a nicely balanced configuration that offers a lot of power without being too expensive."

$4,199 | dell.com/en-au

Alienware Aurora R9

Is Alienware's PC powerhouse a bright spot in the gaming hardware scene or just another flash in the pan?

Alienware's Aurora R9 was released earlier this year and while it's taken a little while for us to cover it, this isn't a reflection on how keen we've been to look at this machine.

The Aurora range from Alienware have traditionally been some of the most powerful pre-built PCs money can buy and the R9 is no different. The Aurora R9 utilises a 9th generation Intel Core i7-9700K, which is an unlocked CPU that can be easily tweaked using the Alienware Command Centre. This bundled software takes a lot of the complications out of overclocking and is a great solution for those wanting the power of a custom machine without having to jump through all the hoops to get one.

It isn't just the CPU that can be controlled from Alienware Command Centre either, you also have the option to tweak GPU and RAM frequencies in a controlled environment that will reinstate earlier settings if any instability is detected.

We tested the Aurora R9 with 16GB of 2666MHz DDR4 RAM and a Nvidia GeForce RTX 2070 Super, for a nicely balanced configuration that offers a lot of power without being too expensive.

When running the PC using stock shipped settings the unit performed within the ballpark of what we expected, lining up with the mobile Intel Core i9-9980HK CPU running on an Aorus 17 with double the RAM. However the CPU never got above 67 degrees, so it was clear there was plenty left in the tank. A little tweaking in Alienware Command Centre and you could push between 5% and 30% more performance from general computing benchmarks.

Once overclocked we were able to get the Aurora R9's i7 to match the performance of the top 10th Gen mobile processor (the i9-10980HK) in a number of benchmarks.

SPECS
Windows 10 Home 64-bit; Intel Core i7-9700K CPU; Nvidia GeForce RTX 2070 Super.

The unit performed nicely with the desktop 2070 Super delivering on games like *Total War: Warhammer II* and *Ghost Recon: Wildlands* comparable with a mobile GeForce RTX 2080 Super (Max-Q). The only outlier in this equation was a disappointing score of 40fps on the *The Division 2* benchmark, about half what we generally get using a mobile 2080 Super Max-Q.

The Aurora R9 has actually been superseded by the Aurora R10 (using AMD parts), which isn't available locally, and also the Alienware Aurora R11 which is basically the R9 with 10th generation CPUs. The Aurora R11 with equivalent specs as the one tested here costs $4,199, which is a reasonable price for the latest components configured to be overclockable out of the box. It's definitely a more expensive process than building your own PC from scratch (or at least it can be), but the Aurora units have a more compact form factor than anything you could easily construct and they'll save you a heap of time setting up software. If you want the best, but don't want to have to build it yourself then this is a great option.

JOEL BURGESS

Indicates best result

	Alienware Aurora R9	Alienware m15 R3
PCMark 8 - Home (score)	4,498	5,297
GeekBench 4 - Single Core	5,312	5,793
Cinebench R20 - multi-threaded CPU	3,293	3,461
3DMark Time Spy (score)	9,155	7,896
The Division 2 - Ultra 1080p (fps Av.)	40	89
Total War: Warhammer II - Ultra 1080p (fps Av.)	85.7	80.7
CrystalDiskMark Read (MB/s)	3,480	3,329.9
CrystalDiskMark Write (MB/s)	2,153	2,451.4

A premium performance PC that makes overclocking easy if you don't mind paying a little extra.

★★★★☆

"What's perhaps most impressive is that MSI has managed to pack all of this extremely powerful tech into such a streamlined and appealing desktop tower."

$6,499 | msi.com

MSI Prestige P100

MSI's new designer-desktop packs a punch, but is it also gentle enough to nurture creativity?

Many creative professionals require PCs that perform at a much higher level than what generally sits on the store shelf, but while enthusiast gamers are generally invested enough to build their own computers, this can be a level of technical knowledge that isn't overly prevalent in the creative professional space. MSI's Prestige range hopes to cater to this growing subset of customers by creating powerful pre-built PCs that offer top shelf performance straight out of the box.

The Prestige P100 is designed to compliment the Prestige PS341WU 34-inch display that we cover on page 32, by ensuring that there's enough grunt to run demanding applications in 5K HDR. The P100 shouldn't have any issues with this since it has a top-of-the-line unlocked Intel Core i9-9900K CPU running the show. This CPU offers a lot of power, with the capacity to encode 4K media at a rate of 15fps it'll chew through computationally heavy tasks and cut down the time taken for heavy creative workflows. The MSI P100 ended up between 15% and 40% faster than the Alienware Aurora R9 (page 28) running an overclocked 9th Gen Intel Core i7.

That CPU is supported by an enormous 64GB allocation of RAM and the fabled power of a Nvidia GeForce RTX 2080Ti for one of the most powerful overall configurations we've tested. For GPU-heavy workloads the 2080 Ti is the most powerful GPU you can get for workloads, without moving into the dedicated workstation GPU offerings. Even the heaviest 3D rendering and CAD usage will seem easy on this overpowered system. That said, MSI has gone a step further offering custom software that will tailor system energy usage to suit the particular workflow you're using. MSI Creator Centre includes system profiles that have been designed specifically for demanding software like Adobe's Creative Suite and AutoCAD and allow you to easily push the computer to peak performance depending on what you are doing.

SPECS
Windows 10 Pro 64-bit; Intel Core i9-9900K CPU; Nvidia GeForce RTX 2080 Ti.

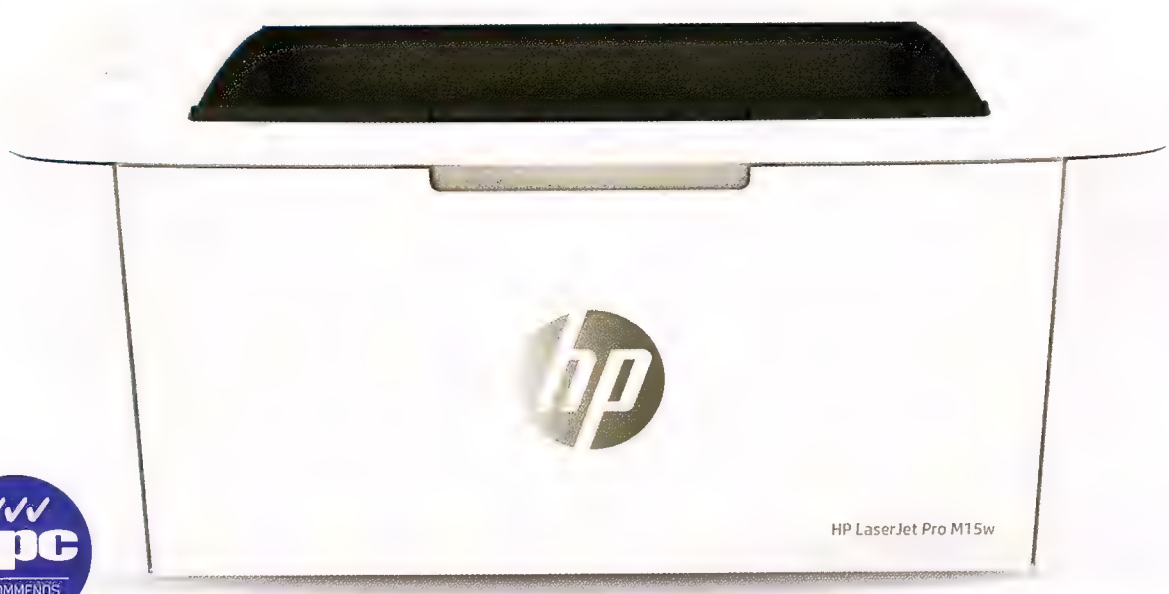
What's perhaps most impressive is that MSI has managed to pack all of this extremely powerful tech into such a streamlined and appealing desktop tower. The P100 comes in either a modern white or space grey colouring with subtle LED lighting and an elegant cascading perforated side vent design, which will appeal to a wide variety of consumers.

The range has since been updated to the P100X and features equivalent 10th generation Intel CPUs which will offer slight computational performance gains over the model reviewed here, but it's worth noting that we took half a point off for MSI's decision to swap from a 2080 Ti to a 2080 Super on the newer highest-specced model. The most similar current model to what we tested is the P100X which costs $6,499, or for those with a slightly tighter budget there are P100X units with a Core i7, 32GB of RAM and an RTX 2070 Super going for $3,999. Either way the P100X is still an impressive creative workstation that will help anyone using demanding applications perform at their peak for longer.
JOEL BURGESS

Indicates best result

	MSI P100	Alienware Aurora R9
PCMark 8 - Home (score)	7216	4,498
GeekBench 4 - Single Core	6063	5,780
Cinebench R20 - multi-threaded CPU	4738	3,293
3DMark Time Spy (score)	12147	9,155
Ghost Recon: Wildlands - Ultra 1080p (fps Av.)	79	64
Total War: Warhammer II - Ultra 1080p (fps Av.)	114	86
CrystalDiskMark Read (MB/s)	3,519	3,480
CrystalDiskMark Write (MB/s)	3,010	2,153

A premium creative workstation that offers top-shelf power without demanding an exorbitant price.
★★★★½



$119 | www2.hp.com

HP LaserJet Pro M15w

Meet the world's smallest budget laser printer.

The HP LaserJet Pro M15w is aimed squarely at the booming micro economy and the legions of workers whose home is also their office, because HP's latest laserjet is not only the smallest in its class, but the cheapest too.

The M15w may be a very basic print-only monochrome printer with just one input tray that will only take A4 and a few smaller paper sizes. You won't find fancy features like duplex printing here and if you require a flatbed scanner, then you should wait for the similarly styled HP LaserJet Pro MFP 28w.

What the M15w offers is a fast printing (19ppm), with the economy and consistency associated with laserjet technology, in a compact unit that takes up little more desk area than a sheet of A4. And while there are few features on board (there's not even an LCD display) it is equipped with Wi-Fi and is supported by an excellent smartphone app, which makes installation easy and adds functionality such as scanning and printing from the cloud.

The enticing price of $119 includes a toner cartridge, which alone costs $80, so your on-going print cost works out to be low.

HP has designed the LaserJet Pro M15w for the micro home office and who would begrudge such an unobtrusive printer on their desk at home? The two trays fold away neatly, so that the footprint is only a little larger than a sheet of A4, and it stands no taller than the average smartphone.

There's no LCD display and only three buttons, which didn't prove to be a disadvantage. It makes no noise at all in standby mode, so this printer won't distract you while you're working. Actual printing it is rather noisy, but it prints quickly, so it won't annoy you for long.

To keep the size and cost of the HP LaserJet Pro M15w to a minimum, the feature-set is also somewhat minimised. There's only room for one paper tray, for example, and that's limited to 150 sheets of A4, or A5 paper, or ten DL, or C4 envelopes. Other sizes can't be fed inside.

Thanks to a slick smartphone app, the HP LaserJet Pro M15w is probably the easiest to install, of any printer we have tested. Just turn the printer on and the app will locate its Wi-Fi signal and get it to join your network. Alternatively, you can connect via Wi-Fi Direct, or the USB cable.

The HP LaserJet Pro M15w printed promptly and reliably throughout the test and churned out pages at least as fast as its quoted 19ppm, if not faster. A4 and A5 paper passes though so quickly that it's almost a surprise to see anything printed on it at all. Only DL envelopes seemed to slow it down, because they only just fit in the tray and rub the sides on the way through.

JIM HILL

"What the M15w offers is a fast printing (19ppm), with the economy and consistency associated with laserjet technology, in a compact unit that takes up little more desk area than a sheet of A4."

The shoebox-sized HP LaserJet Pro M15w can print a thousand documents consistently and quickly on a single toner cartridge and costs less than many of its inkjet rivals.

★★★★☆

"Once that was done we were promised a 10-minute setup process. Oh, if that were true!"

$429 | www.amazon.com.au

Eero mesh Wi-Fi system

Amazon promises fast and simple mesh Wi-Fi from its Eero sub-brand. But does it deliver?

Eero is a mesh Wi-Fi system that promises to make upgrading your wireless network a simple process. It's available for purchase as a single node ($199) which covers 140m² or in a $429 three pack which covers $460m². It promises to act as a single, stand-alone router that can connect directly to your modem. Plus, that its network is easily expandable, that it works with your existing internet service provider, that it takes minutes to set up and that it gets better over time thanks to automatic updates. The problem is that absolutely none of this is new.

Eero does have something going for it, though – the company was acquired by Amazon in 2012 and subsequently should work well with the tech giant's other, Eero, smart-home devices. We've also found that there's no all-conquering mesh Wi-Fi system in the current market. Could the Eero be the one to plump for?

Our three-node system came well presented with the box containing three, smart-looking, glossy, white nodes, resting above a welcome card which describes a four-stage set-up. Each node has two Gigabit Ethernet ports and a USB-C port for power. The box also includes three separate USB-C chargers and a 1m Ethernet cable. The card told us to download the Eero app and follow the instructions. Once that was done we were promised a 10-minute setup process. Oh, if that were true!

If you don't tick the 'agree to be spammed with promotions' tickbox, setup won't progress. It took us multiple resets, form-refilling in and a frustrating 45-minutes to get past this foible. Then we finally moved onto, what felt like, a 20-step process that repeatedly asked us to activate and deactivate things. Why have we dwelled so much on this? Because there's not much else to write about.

Once up and running the app is simple and intuitive to use, not least because there aren't many features. One tab does allow you to enable Amazon Wi-Fi simple setup to help make Echo devices like smart speakers and Fire TV sticks connect more easily to the network, but it relies on you linking your Eero account to your Amazon account, which can't be done through the app. An "Eero Labs" Beta program allows you to preview new features and network improvements but they're all commonplace in competitors. There's not much to get excited about.

SPECS
Technology: Dual-band 802.11ac | Connectivity: 3x 2 Gigabit W/LAN | Features: parental controls, Amazon W-Fi setup, Apple HomeKit compatible.

We ran our performance tests in a three-storey Sydney townhouse, downloading large video files from an Synology 1019+ NAS to a Dell XPS 15 OLED laptop. Up close the Eero managed a decent transfer speed of 316Mbps but this dropped considerably to 112Mbps when one floor up and 88Mbps two floors up – speeds are in-line with many rivals.

At $199 for a single node and $429 for three, it's very pricey, especially when compared to the Officeworks-supplied rival from Tenda which costs just $196 for three nodes. In the face of all this, we can't recommend the Eero, it will only suit buyers who are already heavily invested in Amazon hardware.
NICK ROSS

Expensive, mediocre performance, limited features and a promise of an easy setup that doesn't hold true. Disappointing.
★★☆☆☆

$2,099 | msi.com

MSI Prestige PS341WU

The gaming giant looks to build a more creative pedigree, but is it a bit beige to catch the eye of creatives?

MSI's been bolstering its offerings for creatives in 2020, and no creative suite is complete without a colour calibrated, high resolution screen. The Prestige PS341WU from MSI is about as high specced as they come, offering a 34-inch, 21-by-9 WideUHD screen with a 5120 x 2160 pixel resolution. While it's not quite the 6K, 220 PPI of one of Apple's Pro Display XDR units, it's enough for high resolution image and video work.

This is backed up by a VESA 600 HDR certification, which is solid for something like a laptop, but is probably around the lower limit of brightness you'd want to be able to get the most out of 10-bit HDR colour profiles. Still this is pretty good for reasonably priced colour calibrated displays. MSI says that it offers a 450nit typical brightness and it'll hit 98% of the DCI-P3 colour gamut, so it's not bright by any stretch but it's capable enough for colour grading or RAW image work. The screen does have presets for swapping between Adobe RGB, DCI-P3 and sRGB which makes it easy to swap between colour spaces if you need to, but you will need a PC with a compatible (or ideally certified) colour output.

While the Prestige PS341WU may not look like an amazing creative work display next to the Apple Pro Display XDR or Microsoft's Surface Studio 2, it does cost less than a quarter of the former and a bit under half the latter, so this isn't really a fair comparison. Microsoft's offering does however, come with all the PC components built-in so it'd probably end up costing a similar amount if you factor in the cost of a suitable workstation or you opt for the P100 workstation MSI designed to go with it (reviewed on page 29).

MSI has designed a bespoke screen management software it calls CreatorOSD. This software connects to the PS341WU over an included USB cable which allows you to adjust screen settings without having to use the screen's on-board controls. Naturally the software offers the ability to easily swap between colour gamuts, but it also includes the ability to easily run Picture-in-Picture software so you can use two separate computers side-by-side on the screen. CreatorOSD also offers sizing tools that'll show grids or rulers alongside your work to show you exactly how big it'll be when printed. This software is a handy bonus that saves you having to cobble together online software for a workaround and it gives you confidence that you're working in the colour space and scale you are supposed to be.

The included monitor stand has a slimline profile and makes it easy to set up at a wide range of heights. Personally we prefer a curved screen, however with certain forms of media this isn't practical so we understand the decision to keep it as a flat panel. Fortunately the Nano IPS display has a wide 178-degree viewing angle, so you don't get any colour loss when looking at the screen's extremities.

JOEL BURGESS

"The Prestige PS341WU from MSI is about as high specced as they come, offering a 34-inch, 21-by-9 WideUHD screen with a 5120 x 2160 pixel resolution."

SPECS

34-inch 21:9 Nano IPS display @ 5120 x 2160 pixel resolution (163PPI); 60Hz, 8ms (GTG) response time; VESA DisplayHDR 600, 450nits typical brightness; 178-degree viewing angle; 1200:1 contrast ratio; 98% DCI-P3, 100% sRGB; AdobeRGB output; DP, HDMI or USB 3.1 Type-C display; 81.7 x 50 x 26cm; 8.2kg.

A decent 34-inch display for those needing professional colour specifications on a conservative budget.

★★★★☆

$1,599 | www.lg.com

LG UltraGear 34GN850

Large and luscious.

On paper, the 34GN850 certainly ticks plenty of boxes. The 34-inch curved panel sports 3,440 by 1,440 pixels. If that's predictable, LG's Nano IPS screen is a bit special. LG says it's good for 1ms response, which puts it on a par with the best TN panels. Impressive.

Speaking of speed and slickness, you also get 160Hz refresh, plus both Nvidia G-Sync and AMD FreeSync Premium support. For the record, G-Sync support is G-Sync Compatible Verified rather than one of the fuller featured G-Sync offerings based on Nvidia's in-monitor image processing chipset.

But what of HDR support, you ask? It's present, but also an area where the LG UltraGear 34GN850 is a little light on spec given the heady price point. You only get VESA DisplayHDR400 certification. That's pretty much the very lowest available rung of HDR certification. So the 34GN850 lacks local dimming and tops out at 400 nits.

Another relative disappointment is the omission of USB Type-C connectivity. Now, it's true that USB-C is arguably not a top priority for gamers, who will mostly be connecting this panel to a beefy desktop rig. But a fair few gamers use portables and, for at least some of them, the ability to drive the display, charge and connect peripherals with a single cable will be missed.

That said, it's a great looking bit of kit with its Vader-esque glossy black plastic and a few flashes of the obligatory "gamer red" to spice things up without tipping over into adolescent over exuberance. It also offers a good range of height and tilt adjustment.

On the subject of great looking things, the 34GN850's LG NanoIPS panel certainly falls into that category. It positively zings with colour and vibrancy. Contrast is great too, which isn't always the case with IPS screens, especially those rated at a mere 1,000:1 for static contrast.

As for the questions of speed and response, the answer is qualified. The 160Hz refresh will be bags for all but the most hair-trigger honed of esports aficionados. Paired with either G-Sync or FreeSync and a powerful graphics card, this monitor is nothing if not buttery smooth.

The pixel response is a little more complicated. LG has included three levels of pixel overdrive in the UltraGear 34GN850's OSD menu. The top setting is very quick, but also suffers from inverse ghosting. The middle setting is a better compromise. Again, it'll be good enough for nearly all gamers. But the most sensitive will recognise that the best TN panels are still that little bit more resistant to blur.

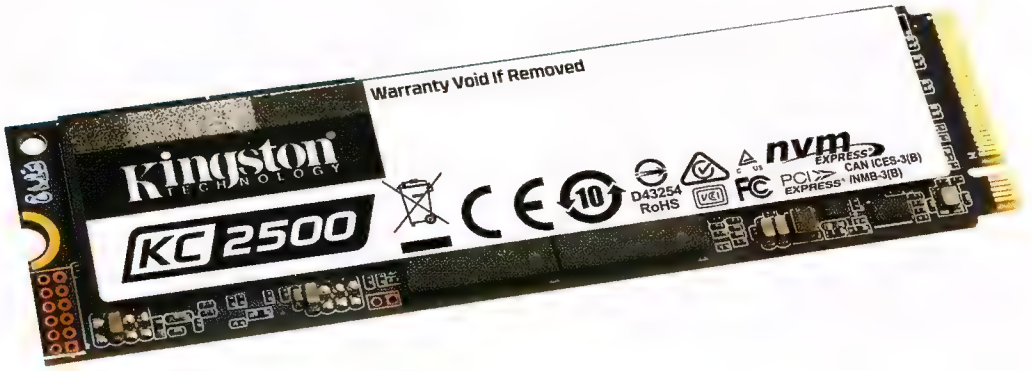
It's a similar story with the HDR capabilities. The 34GN850 is a clear cut above a typical SDR display for brightness and dynamic range. But it doesn't get close to the eye-pummeling punch of a true HDR screen.

The bottom line? Almost all games look gorgeous on LG's UltraGear 34GN850. But improved HDR capability and the addition of USB-C would make it easier to swallow that prodigious price tag.

JEREMY LAIRD

LG's luscious new 34-inch 160Hz NanoIPS monitor is a gamer's delight. But it comes at a heck of a price.

★★★★☆



apc RECOMMENDS

$90 (250GB), $190 (1TB), $570 (2TB) | kingston.com

Kingston KC2500 M.2 NVMe SSD

Kingston's KC2500 is a capable Self-Encrypting Drive (SED) built for high performance.

Kingston's new KC2500 leverages the same components as its predecessor, the KC2000 from 2019. But this time around the firmware has things cranked up a notch. With Silicon Motion's SM2262EN and Kioxia's latest BiCS4 96L TLC NAND flash, it can hit read/write speeds upwards of 3.5/2.9 GBps. And with XTS-AES 256-bit hardware-based encryption on top, it's an ideal business-class storage device for your laptop when on the go, or for a high-performance workstation at the office. Its only fault is its high price when purchased in low volume.

Kingston's KC2500 comes with mature 96L TLC that can operate at the higher speed needed to be competitive, without sacrificing long-term reliability. With this boost, Kingston's KC2500 is capable of delivering much faster sequential performance across the capacity range. Kingston has increased the interface speed from 525 MT/s up to 650 MT/s, a 21 percent speed increase along with other firmware optimisations, helping improve sequential performance by up to 28 percent.

With a PCIe 3.0 x4 link, the company rates them to deliver sequential performance of up to 3.5/2.9 GBps read/write and hit upwards of 375,000/300,000 random read/write IOPS, a significant boost over the previous model. That equates to a 500 MBps bump in read/write performance at the 500GB capacity and 300/700 MBps read/write improvement at the 1TB and 2TB capacities. Furthermore, in order to deliver such high write speeds, Kingston has implemented a decently sized dynamic SLC write cache to absorb inbound requests. But once it fills, write speed will degrade until ample idle time allows it to recover.

For those working with more sensitive data, Kingston's KC2500 is a self-encrypting drive (SED) that features XTS-AES 256-bit hardware-based acceleration that is TCG Opal 2.0 compliant and meets IEEE-1667 specs (and Microsoft's eDrive, too). The XTS bit is important to note because utilising XTS block cipher mode provides stronger data protection over other modes – it uses two AES keys.

With Silicon Motion's SM2262EN is at the heart of Kingston's KC2500, paired with Kioxia's BiCS4 96L TLC, these make for one of the most responsive SSD hardware combos going. Kingston's firmware optimisations have led to drastic increases in this SSD's performance across the board. With the SLC cache adjusted to deliver higher performance sooner during transfers, Kingston's KC2500 is more responsive to requests than almost any other SSD available. It thrashes workstation and prosumer workloads and is a top dog when it comes to game data loading.

That said, it isn't the most efficient contender when copying around large datasets. And, while Kingston's KC2500 features some very secure encryption and responsive performance most of the time, pricing is an issue and it has some very tough competition. If the XTS-AES 256-bit encryption isn't a requirement, we'd recommend you check out the Corsair Force MP600 or Samsung's 970 EVO as premium alternatives.

SEAN WEBSTER

With secure XTS-AES 256-bit SED capability and one of the most responsive SSD hardware combos on the market, Kingston's KC2500 is a fantastic SSD for prosumer use.

★★★★☆

$69 | www.bequiet.com

Be Quiet! Pure Rock 2 CPU Cooler

Affordable and quiet air cooling.

Don't forget air cooling! These days there's a lot of emphasis on closed loop water coolers but in many use cases these are overkill both in terms of unnecessary complexity and expense. The Be Quiet Pure Rock 2 is a cost-optimised single tower cooler that can dissipate up to 150W, making it a capable option for all but the highest-end mainstream 2020 processors.

Be Quiet! is a German manufacturer, and as the name suggests, it offers products including cases, coolers and power supplies designed with an emphasis on low noise levels. Low noise optimisation and marketing is perhaps one of those things that has retreated a little in recent times with the trend towards the need to cool high TDP processors, the emphasis on RGB bling and the explosion of more complex AIO cooling. It's nice to have coolers aimed at users who want to enjoy, but not see or hear their PC. The Pure Rock 2 is one such cooler. In a darkened case, it's all but invisible. Having said that, it is an attractive cooler with its black fins and fan. It will appeal to those users who are turned off by RGB light shows that are common among 2020 fans and coolers.

The bundled Pure Wings 2 fan is a 120mm PWM model that really is silent in its operation. It does spin up and become audible under full load but at no time was it even remotely intrusive. In fact it's one of the quietest fans we've ever heard.

Installation is straightforward, being similar to other air coolers. It can be oriented in both directions depending on your case design. We weren't big fans of the fan installation with the wire retention clips requiring a bit of fiddling to get installed correctly. We ended up denting a few of the cooler's fins before getting it right. It's just a niggle though, as once it's done, it's done.

We tested the Pure Rock 2 with an AMD 3900X twelve-core CPU. We chose it because it's a good match for the 150W TDP rating of the cooler, whereas something like a 10900K is a step beyond it. Remember this is not some $250 plus cooler, but a $69 one. You can't expect too much. Under full load we saw a peak temperature of 75c during loops of Cinebench. Not bad for an affordable air cooler tasked with cooling a 24-thread load! This is about the limit of the cooler though. If you're interested in overclocking or running 10th Generation Intel 8 or 10-core CPUs we'd go for something designed with a little more capacity. A 65W CPU will be right at home when paired with a Pure Rock 2.

We're very pleased with the Be Quiet Pure Rock 2. It's not designed to be an overclocker's dream cooler but at its affordable price, it's highly recommended and a good step up from bundled coolers. Just make sure you pair it with an appropriate CPU. If paired with a 65W Intel or AMD CPU, we're positive that this is a cooler that's perfect for the job. Unseen and unheard.
CHRIS SZEWCZYK

"It's nice to have coolers aimed at users who want to enjoy, but not see or hear their PC"

SPECS
Be Quiet! Pure Rock 2 Black CPU cooler; up to 150W TDP cooling capability; AMD AM4, AM3(+) & Intel 1200, 2066, 1150, 1151, 1155 and 2011(-3) compatible; 1x Pure Wings 2 black 120mm PWM fan; max 26.8 dB(A) noise level; 3 year warranty.

The Be Quiet Pure Rock 2 is an affordable and effective cooler that really is quiet.
★★★★½

$219 | phanteks.com

Phanteks Eclipse P500A

Maximum mesh.

Phanteks offers a massive variety of PC cases, from hulking full towers to diminutive ITX boxes. Yet they're still finding holes to plug within their own range, and that's what the P500A does. It's not the most expensive Eclipse case, but it's still a large, premium case with space for E-ATX boards.

Airflow is the name of the game here. The entire front panel is carved from a single flat piece of metal and employs Phanteks's "ultra-fine performance mesh," with 1mm perforation that provides a large, flat surface for air intake. As any mesh-heads will know, mesh cases eliminate the need for removable dust filters, allowing for superior airflow.

Three 140mm D-RGB fans (or two plain black ones if you opt for the cheaper RGB-less model) sit behind that mesh panel. Connected to a software-less RGB controller inside the case, these draw in plenty of air to be vented through the rear and roof of the case. The P500A doesn't come with a rear fan, but transplanting one of the front fans shouldn't be hard. A single 140mm fan also isn't that expensive.

Speaking of pricing, this P500A will run you around $220. It's not the cheapest RGB mid-tower case we've ever seen, but the metal and tempered-glass construction here feel up to snuff for the cost. It comes with removable roof and base dust filters, and an accessory kit packed with extras.

This is something of a feature-heavy case. The RGB fans are joined by a matching light strip that runs across the PSU shroud, all behind a hinged glass window utilizing a triple-fin rubber seal to reduce system noise. It's not perfect, as the mesh front panel lets noise out, but it's a welcome inclusion. There's room for more fans or radiators, with up to 360mm of radiator space in the roof should you decide to liquid-cool your build.

Storage is fully handled here, with mounts for up to three 2.5-inch SATA drives behind the motherboard, and 10 slots (six within the case cavity, four underneath the PSU drive) where HDD brackets can be mounted. The case comes with only two of these brackets included.

Similarly, a bracket to vertically mount your GPU is included, but the required flexible PCIe riser isn't. And four drilled holes in the roof of the case allow for a secondary ITX system to be installed, but the bracket and miniature PSU needed are sold separately.

There's a lot to enjoy in this case, though. For example, cables can be tidied using the sliding plates attached to the central mounting plate. They're simple to use: Slide them open, feed your cables through, then slide them back into place and lock them with the attached thumbscrew. The D-RGB lighting uses colour and pattern presets that can be changed via two buttons on the front I/O, and the I/O also includes USB Type-C.

In short, this case has everything we'd expect. It's hard not to like. Those HDD cages can hold 2.5-inch drives too, so there's basically no case within this price range that can compete on a storage capacity level. We've seen better premium mid-tower cases, but they are also more expensive.

Solid value matched with solid construction makes this an attractive option for anyone looking to build a powerful gaming system or workstation.
CHRISTIAN GUYTON

Excellent airflow; a solid construction; lots of features.

★★★★½

apc HOT PRODUCT

$229 | logitech.com/en-au

Logitech MX Keys for Mac

A sleek, solid and backlit alternative to Apple's own.

While there are countless peripheral options for Windows-based systems on the market, it can be a little tricky finding anything as solid for Mac outside of Apple's own line of Magic Keyboards and Mice. Thankfully, Logitech has brought its much-celebrated MX series to the Mac, offering the same sleek operation and style as its PC counterparts but with those final touches that make it truly integrate with your Apple ecosystem.

Of those extra tweaks, the most obvious are the macOS-specific key layout and language, and the striking Space Grey finish (which is still quite pleasant to look at, no matter how used to it we are). Other than these changes (and the included USB-C to USB-C cable to better communicate with your latest MacBook), the two MX Keyboards are identical. This is great news for Mac users as it means you'll be getting the same awesome backlighting from the regular MX Keys, which automatically adjusts to the ambient light as well as turns on and off when it detects your hands' proximity.

As is the case with previous Logitech peripherals, you can use 'Flow' with the MX Keys. This means that you can register up to three devices, have them simultaneously connected to your keyboard, and switch between each device with a dedicated button. This is great if you work across a MacBook, Mac and iPad, for instance. You can even copy and paste files and text from one machine to another, provided they're on the same Wi-Fi network. The Logi Options app is intuitive to use and allows you to customise each of the function keys, backlighting controls, and Flow settings, as well as other advanced options like battery saving mode and notifications for caps lock.

Compared with Apple's Magic Keyboard with Numeric Keypad ($219), Logitech's MX Keys have the exact same layout and spacing but have a tiny bit more travel, although it's still quite flat and minimal. They're also more on the 'spongey' side of things rather than 'snappy', but we found both to be sensational to type on and purely a matter of preference. Logitech's keys are also more indented compared with Apple's relatively flat tops (which more or less mimic the latest MacBook keyboards). The MX is a bit larger than Apple's offering – sitting ever-so-slightly higher off the desk and with a steeper incline – and is a good degree heavier too. This later factor is most likely due to its backlighting and bigger battery, which can last 10 days on a full charge or five months with backlighting switched off, compared with Apple's single month.

Ultimately, while the feeling of typing on the keyboard is purely a matter of preference, the other factors that differentiate the MX Keys from Apple's own Magic Keyboard are easy enough to weigh up. Logitech's option is great if you're in a situation where backlit keys would come in handy, or if you frequently swap between multiple devices you'd like to type on. If both apply, then the MX Keys for Mac is about to become your new best friend.

HARRY DOMANSKI

A single keyboard that can control up to three devices, and is a joy to use with typical Logitech quality and thoughtful design..

★★★★½

"The display is a vibrant 6.5-inch AMOLED number which, save for a small punch-hole selfie camera, is largely uninterrupted. It's curved at the edges, similar to Samsung's Galaxy S flagship range, which makes for a very comfortable and slim-feeling grip in the palm."

apc HOT PRODUCT

$999 | oppo.com/au

Oppo Find X2 Neo

The marriage of premium and affordable never felt so good.

It's been a year since we reviewed the Oppo Reno 5G, and both the Chinese phone manufacturer and the 5G network have come a long way in that time. That handset and the newly launched Find X2 Neo share many similarities, but with a retail price $500 less, is the Neo better suited to today's market?

Available in either blue or black – both of which are subtly iridescent – the Neo offers a decent balance between flashy, premium looks and a more subdued item that's novelty won't rub you the wrong way after a few weeks.

Both the face and rear of the phone are minimal, with the latter home to small Oppo branding and the quad camera array, and the former comprised almost entirely (89.7%) of its gorgeous display.

The display is a vibrant 6.5-inch AMOLED number which, save for a small punch-hole selfie camera, is largely uninterrupted. It's curved at the edges, similar to Samsung's Galaxy S flagship range, which makes for a very comfortable and slim-feeling grip in the palm.

Powering the Find X2 Neo is one of Qualcomm's upper-mid-range chipsets, the Snapdragon 765G, one of the first to fully integrate 5G tech. This is great for battery performance, with the 4,025mAh cell lasting much longer than other equivalent handsets.

You'll get an insane 12GB of RAM, which – coupled with the 90Hz refresh rate in the display and plenty capable chipset – makes for a solid gaming platform. And while there's no SD card slot, the 256B of on-board storage should be enough for most users in this cloud-based age.

Considering the crazy benchmark that smartphones have set for camera capabilities, it can feel a little harsh when saying that something as powerful as the Find X2 Neo doesn't compare to its more expensive competition.

If you're absolutely after top-of-the-line camera specs you can't go past the Google Pixel range or the Neo's elder sibling, the Find X2 Pro, but for those seeking merely excellent photo and video capabilities, the Neo still performs better than most in its price category.

SPECS

Qualcomm Snapdragon 765G; 90Hz 6.5-in 1080 x 2400 AMOLED screen; 256GB /12GB RAM; quad front cameras (48, 13, 8, 2MP); 32MP selfie camera; Wi-Fi 802.11 a/b/g/n/ac; 4025 mAh battery; 159.4 x 72.4 x 7.7 mm; 171g.

Last year when we reviewed the Reno 5G, Australia's 5G network was in its infancy and the range of compatible phones were limited. There are now manifold options available – some of which are even cheaper than the Find X2 Neo – and the network itself is more capable around major city areas (although still far from perfect).

This means that it's way less of a novelty to invest in the technology now, but it also means you can be pickier about the handset you choose – thankfully, the Neo is a good choice.

A lack of wireless charging, SD card slot and headphone jack are, for the most part, easy to forgive given the price point, but a complete absence of a waterproof rating holds it back from the everyday ruggedness we'd like to see.

HARRY DOMANSKI

There are cheaper handsets that'll get you on the 5G network – Xiaomi's Mi Mix 3 5G and Samsung's A71 5G for instance – but Oppo's Find X2 Neo does a much better job of making its compromises less critical and, as a result, is very easy to recommend.

★★★★½

"The most thorough noise-cancelling we've ever experienced by far. Everything from low traffic rumbles to voice chatter and even wind is comfortably excluded."

AU$549 | sony.com.au

Sony WH-1000XM4

The king is dead, long live the king.

There's an unsurprising heir to the wireless, noise-cancelling throne, and while Sony certainly hasn't strayed far from its regal headphone lineage, the WH-1000XM4 is better for it. Quite frankly, it was hard to imagine what could be improved upon when reviewing the forebears to these new cans, but Sony has added enough polish to the WH-1000XM3 crown to keep its gleam intact and add some new precious gems in the process.

From a design sense, very little has perceptibly changed – the lightweight, comfortable, and subtly stylish pair of headphones that you're used to has returned unscathed. You won't be able to see the real improvements as they're all under the hood, but you'll certainly encounter them. Perhaps the most obvious is a retooling of the crown jewel – noise-cancelling. While the M3 already had class-leading ANC, the M4 features an upgraded algorithm on its dedicated QN1 processor along with a brand new Bluetooth SoC (System on Chip) that adjusts the noise-cancelling 700 times every second based on environmental noise picked up through two pairs of external microphones. In practice, this translates to the most thorough noise-cancelling we've ever experienced by far. Everything from low traffic rumbles to voice chatter and even wind is comfortably excluded. Specifically, the improvements over the previous iteration are especially prominent in the mid-to-high frequency ranges. Where some headphones suffer from a particularly strong 'vacuum' effect when enabling ANC, the Sony's feel comfortable in every situation we've tested them in.

A new and genuinely useful feature is Speak to Chat, which automatically pauses your audio and lets in ambient sound when the headphones detect that you're speaking. This feature, coupled with Quick Attention (hold a hand over your right earcup to let in ambient sound immediately) make for a powerful pair of tools for navigating the outside world when wearing these otherwise thoroughly immersive cans. You'll also now find support for Sony's 360 Reality Audio, although you'll need a media source that supports it (Deezer and Tidal, for instance).

With Sony's Headphones app, you'll be able to tweak all kinds of settings to truly customise your own WH-1000XM4 experience. On top of the aforementioned features, you'll be able to adjust smart assistant integration, 20 different degrees of noise-cancelling, whether to let in voices or not, and an adaptive mode that can use your location to automatically adjust audio and ANC settings dependent on frequently visited locations (commuting, home, and office are some obvious ones).

As for the audio itself, this has also been given an edge over that of its predecessor thanks to Edge-AI and DSEE Extreme processing. These two features offer a more advanced system for upscaling otherwise compressed or low-res audio signals (such as from a streaming service) into something closer to lossless. Sony's warm but clear sound signature (a slight but pleasant bass boost and incredible separation and clarity across the board) is present here and sounds gorgeous out of the box, but a five-band EQ is available in the app for further tweaking.

If you already own the WH-1000XM3 or manage to find them at an especially good price, they are still exceptional headphones and the improvements in the XM4 might not be worth the cost of upgrading. For everyone else, these are the very best you can get.
HARRY DOMANSKI

SPECS
40mm drivers; 4-40,000Hz frequency response; Active noise-cancelling with Quick Attention and Ambient mode; 30-hour battery life with with ANC (38 without); USB-C and 3.5mm port; Black or Platinum Silver; 254g.

The best noise-cancelling headphones in the world just got better, and you need them.
★★★★★

WINDOWS

Adobe Photoshop CC 2020 | Photography bundle $14.29/Mo | www.adobe.com
Affinity Photo 2020 | Single purchase US$79 | www.affinity.serif.com

Adobe Photoshop CC 2020 vs Affinity Photo 2020

In the battle of the image-editing apps, there's only one winner: the users.

The world of professional image-editing applications is not a wide one. There's Adobe Photoshop, and then there's everything else: Maybe PaintShop Pro or PhotoPaint from Corel, or the open-source GIMP, or Paint.net if your needs aren't very great. Then Serif, maker of the also-ran app Serif PhotoPlus, decided to play Adobe at its own game with the Affinity suite. First came Affinity Designer, then Affinity Photo, then Affinity Publisher, rivalling Illustrator, Photoshop, and InDesign in terms of features and usability.

Serif is quick to retweet stories on social media of professionals abandoning Photoshop for Affinity Photo, often underlining the difference in payment schemes adopted by the two software developers. But just how similar are the two programs? And can someone who's been using Photoshop for 20 years navigate a new app?

Perhaps the biggest difference between the two apps is the way you pay for them. Photoshop is part of Adobe's notorious Creative Cloud suite of subscription-only apps, but differs slightly in that it can be obtained (along with RAW-processing and image-organisation app Lightroom) as part of the bargain-priced Photography Plan, which at $171 for a year is half the price of a subscription to any other single app. Alternatively, you can splash out $875 a year for the entire software suite, which numbers more than 20 apps.

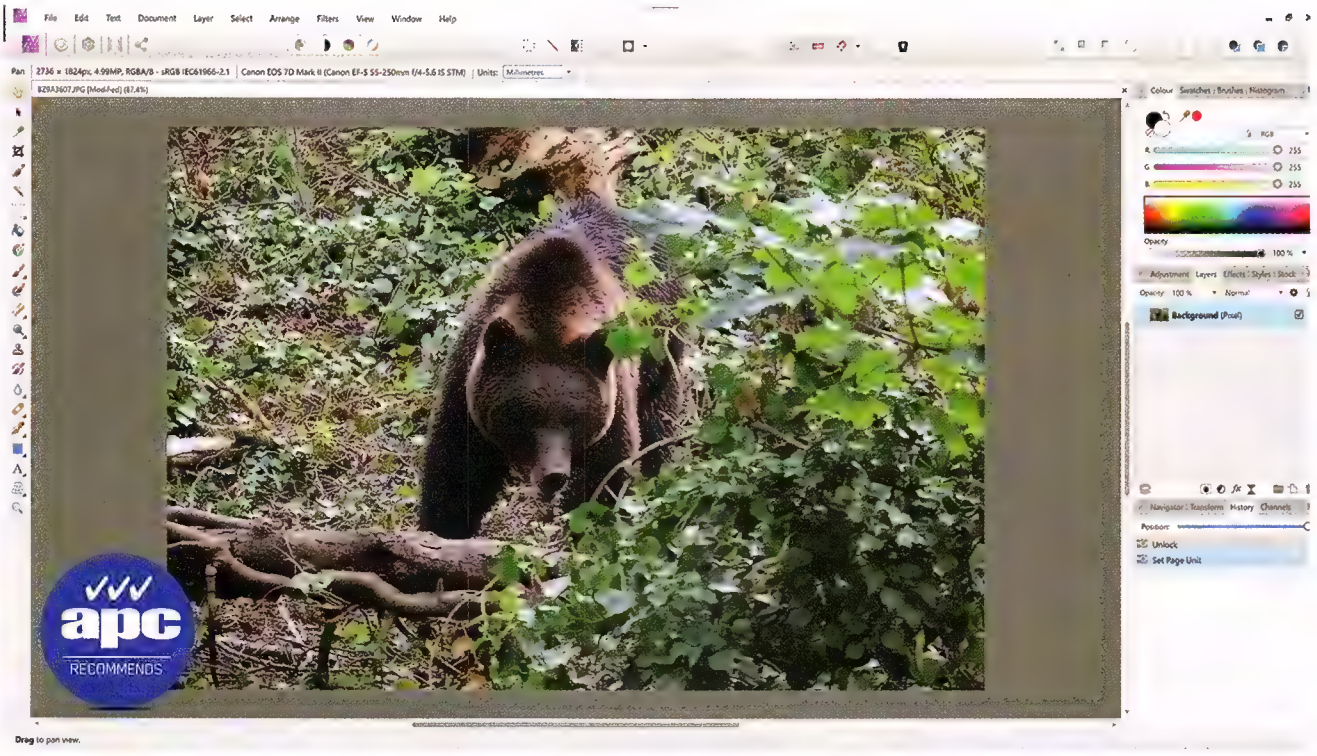
Affinity does things the old-fashioned way. For US$79.99 you get the desktop app, and another US$30.99 on top nets you the iPad app. You're free to add the other two apps in the suite too for the same price, except that Publisher doesn't have an iPad app yet. All updates are then free. Some people prefer this, as they don't like the idea of renting software, while others prefer the subscription model. It's a matter of personal taste, but whichever app suite you choose, you're stuck with its pricing.

Adobe's Photoshop has reigned as the editing king thanks to its unmatched range of tools.

A new challenger

The two apps are both layer-based raster image editors with vector capabilities, and Affinity Photo has clearly been made with Photoshop users squarely in mind. From the gray background (adjustable, and there are light and dark modes) to the interoperability with Photoshop's PSD files and plugins, to the positions and names of tools and palettes, this is the sincerest form of flattery.

Possibly the best thing Affinity ever did, however, was to sting Adobe into action. Just as Intel's CPU lineup had stagnated until Ryzen came along, so Adobe's updates were decidedly pedestrian before the release of a serious rival. Since then, however, it's gone nuts. New content-aware



Affinity Photo offers a powerful suite of tools and a more conventional pricing structure.

features, some of which make use of Adobe's Sensei AI cloud tech, make selecting difficult features, such as curly hair, much easier. Content-aware selection is now able to detect whether the object being selected is a person, and changes to a different set of algorithms if it is. Affinity has updated its own selection tools with a "Selection Brush" and "Refine" window that works like "Select & Mask" – but Adobe's ahead here.

Sensei also comes into play with the new "Match Font" feature, which will identify fonts used in signs or shopfronts you've photographed, and match them to something similar on Adobe Fonts. It works across multiple lines, and even with vertical text.

Meanwhile, Serif has been concentrating on catching up to Adobe in other areas. Affinity Photo now supports "smart" objects (layers are smart in Affinity Photo by default, without needing to be converted, so can be resized non-destructively), and has full compatibility with DXO's Nik Collection of plugins, which apply their own algorithms to things like noise reduction, sharpening, geometric corrections, and film simulations in ways that are popular with many photographers and image editors. With more than 200 presets, you're never short of a place to start.

And while Affinity Photo may seem to lag behind, it's an app that's still in active development. For example, while the Mac version works with multiple GPUs, that feature hasn't come to the PC at the time of writing, but is promised in a future update. Affinity's major advantage over Photoshop comes in its usability: the Affinity interface is split into different workspaces, which it calls "personas," each of which has a specific task. So there's the "Develop" persona for dealing with RAW image files, the "Photo" persona where the bulk of the editing takes place, the "Liquify" persona for warping effects, the "Tone Mapping" persona for HDR, and the "Export" persona for, well, exporting.

In addition, the three Affinity apps support StudioLink, which allows Affinity Designer users to edit an image right there in the layout app but invoking the photo-editing app's tools. Flicking from InDesign to Photoshop and back if you want to correct something in an image file doesn't take long, but with StudioLink it's pretty much instant. The apps are also built around a common file format, so you can open a Publisher document in Affinity Photo and edit it as if it were an image file.

Serif has lavished attention on Affinity Photo's "Move" tool, which works with the "smart" nature of layers to make resizing an object easy, rather than Adobe's habit of making you jump through a couple of hoops first. Then there are Affinity's live previews, which show exactly how your chosen combination of brush, colour, and opacity settings will paint before you do it – something Photoshop doesn't have. Otherwise the two apps are both excellent layer-based raster image editors, and you can't go wrong with either.

Choosing between these apps is like choosing a racehorse. Do you go for the established champ, or the up-and-comer who might stand a chance of leading the field one day? A lot will come down to your views on subscription pricing – and if your clients demand an Adobe workflow, then there's no substitute. But don't rule Affinity out: It does a lot right, and if the improvements keep coming the way they have been, it really does stand a chance of coming at the king, and not missing.

IAN EVENDEN

Adobe Photoshop CC 2020
Industry standard; interesting Sensei tools; ties into the CC suite.
★★★★½

Affinity Photo 2020
Single purchase; solid foundations; Affinity StudioLink.
★★★★☆

MACOS X 10.9 or later | US$69.99/year (one Mac) | intego.com

Intego Premium Bundle X9

Premium malware protection designed for your Mac.

Intego is designed to stop malware on Macs, and there are two purchase options depending on the scale of protection you're after. You can purchase Intego's basic antivirus, Mac Internet Security, by itself, but the entire protection suite – Mac Premium Bundle – also includes a vulnerability scanner, system cleaner, parental controls, and a firewall.

During the test, a compressed file with over 130 malware designed to attack Mac devices was downloaded. Intego blocked 97% of these threats including spyware, worms and Trojans. Five threats were able to sneak in disguised as legitimate Mac programs. However, after a deep virus scan with Intego, these remaining threats were found and immediately quarantined. Overall, Intego does very well in recognising and stopping malware before it infects your computer.

In addition to its VirusBarrier, Intego Premium Bundle comes with Washing Machine, NetBarrier and ContentBarrier. Each contain more security tools to add additional layers of protection around your entire system. You also get Intego's Personal Backup to create a second set of files to keep safe in your cloud storage account, in case you need to reboot and reinstall important files and programs. The Intego bundle is several separate apps that are downloaded individually. It's a simple process, but it takes time. You have the option to only install programs you want and disregard others, but overall it's easier to download one app with all the features and tools rather than several, broken up apps.

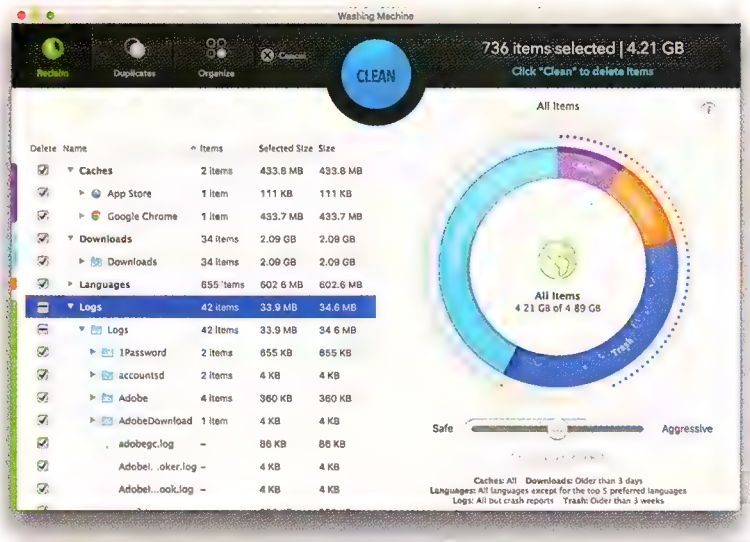
Another issue is the lack of safe browsing tools. Unlike other apps that include browser extensions, Intego simply lets you know if your browser's own security settings are on or off. There are a few other advanced security tools that are not included as well – safe banking tools, password management, and a VPN.

Finally, while Intego recognises and stops Mac threats, it doesn't work for Windows threats. Windows malware won't affect your Mac, however it's easy to accidentally send a Windows threat on through email or instant message.

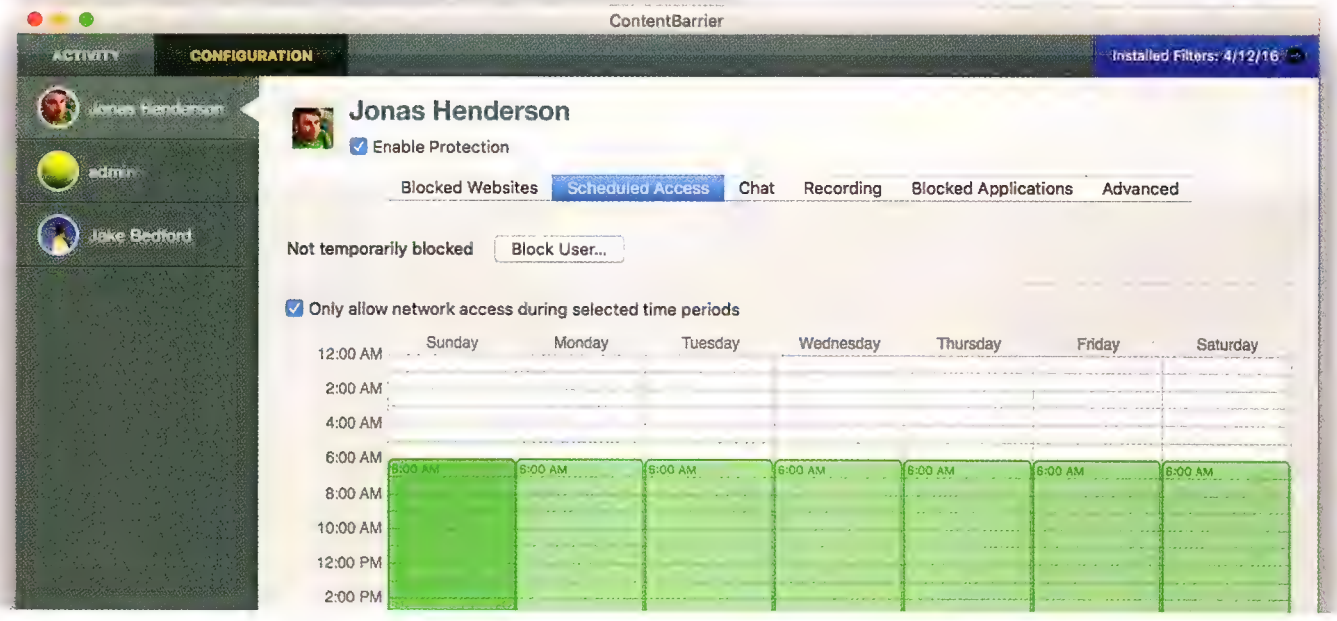
NICOLE JOHNSTON

Excellent malware protection, and much more, made specifically for Macs.

★★★★☆

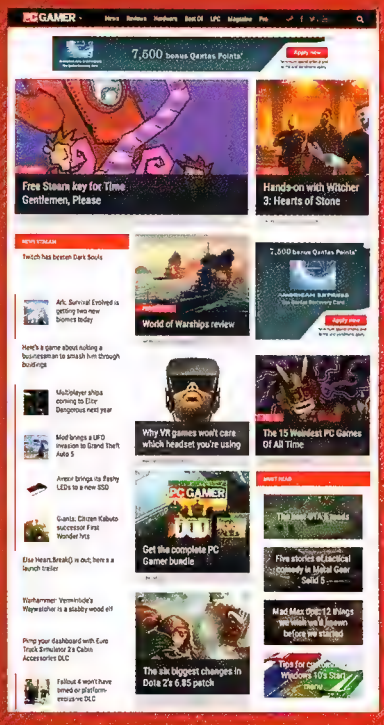


Apps within the Intego bundle need to be downloaded and installed individually, which is time-consuming.



Below: Intego's advanced tools protect you against hackers, ransomware and inappropriate content.

SMARTER COOKIES ENABLED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7,600 bonus Qantas Points*
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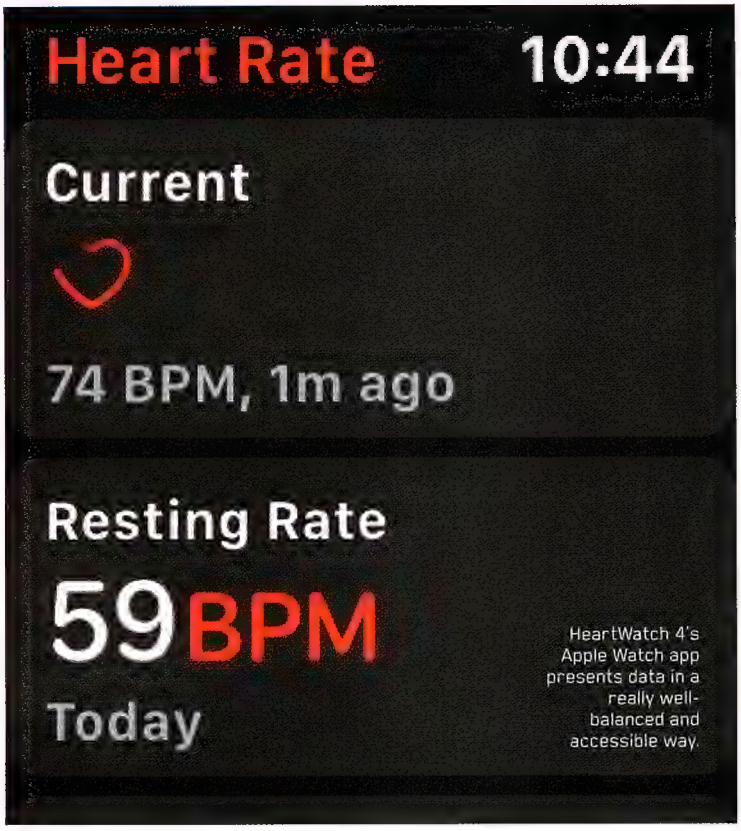
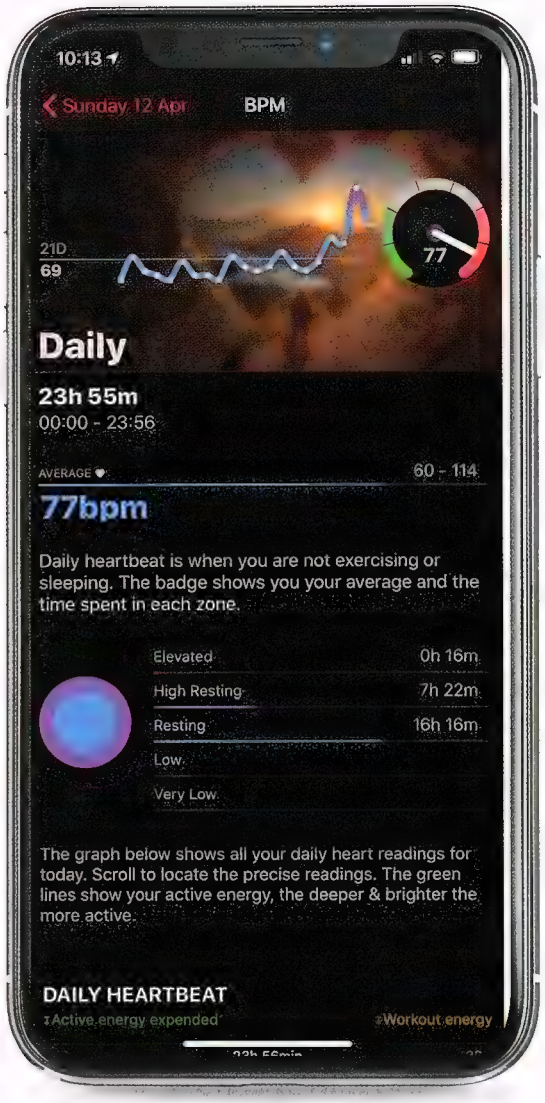


HeartWatch 4's Apple Watch app presents data in a really well-balanced and accessible way.


10:13
Sunday 12 Apr
BPM
21D
69
77
Daily
23h 55m
00:00 - 23:56
AVERAGE
60 - 114
77bpm
Daily heartbeat is when you are not exercising or sleeping. The badge shows you your average and the time spent in each zone.
Elevated 0h 16m
High Resting 7h 22m
Resting 16h 16m
Low
Very Low
The graph below shows all your daily heart readings for today. Scroll to locate the precise readings. The green lines show your active energy, the deeper & brighter the more active.
DAILY HEARTBEAT
Active energy expended
Workout energy

HeartWatch's daily summaries give you plenty of detailed information to delve into to reveal your stats.

$5.99 | needs iOS 11 and watchOS 4.0 or later | heartwatch4.tantsissa.com

HeartWatch 4

Keep an eye on your heart.

HeartWatch's stated goal is to make it easy to understand your heart health. It attempts to do this through pairing with your Apple Watch and breaking down its treasure trove of data into various charts and graphs, learning from your activity levels and suggesting new targets and goals.

HeartWatch has a chart for every kind of heart-related data you could wish to access. It uses tiles to show each section's summaries; drilling down into a specific section provides a wealth of useful data, all presented in an attractive, digestible way, along with suggested fitness targets based on your historic info. When put together with the horde of other tiles in the app, each bulging with info, it can feel a little overwhelming.

HeartWatch's home screen starts with a week view along the top, with your selected day's data below. A swipe changes each tile from showing a circular or bar graph to a gauge, much like a car's speedometer. Tap on the tile and you get a daily breakdown of that metric, down to almost the minute-by-minute level. A long press reveals bar graphs for various measurements, such as sedentary heart rate, workout duration, sleep quality, and more. It's a huge array of info and knowing where to start can be a little intimidating.

It is, however, a data nerd's dream. While there's a ton of information, it's all presented in a highly understandable way that shows you exactly how you're doing over time. In short, it's a goldmine. Compared to Apple's Health app, Health feels like the entrée, whereas HeartWatch is the main course. After using HeartWatch, Apple's attempt feels just too basic.

"It is a data nerd's dream. There's a ton of information all presented in a highly understandable way that shows you exactly how you're doing"

HeartWatch's Apple Watch app, meanwhile, feels perfectly balanced between accessibility and detail, providing just what you need for a quick update on your heart health. Its complications are useful, and its settings can be easily tweaked.

Should you get HeartWatch? The simple answer is yes. Not only does it present your heart data in a more understandable way than Apple's Health, but it does so while providing much more detail – no mean feat. With a little practice to overcome the information overload, it's a fantastic tool.

ALEX BLAKE

HeartWatch4 is a goldmine of data to help your heart stay healthy.

★★★★☆

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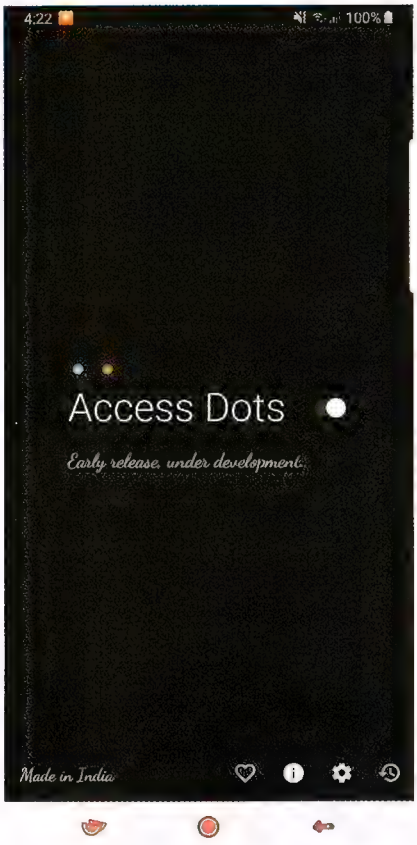
FUTURE



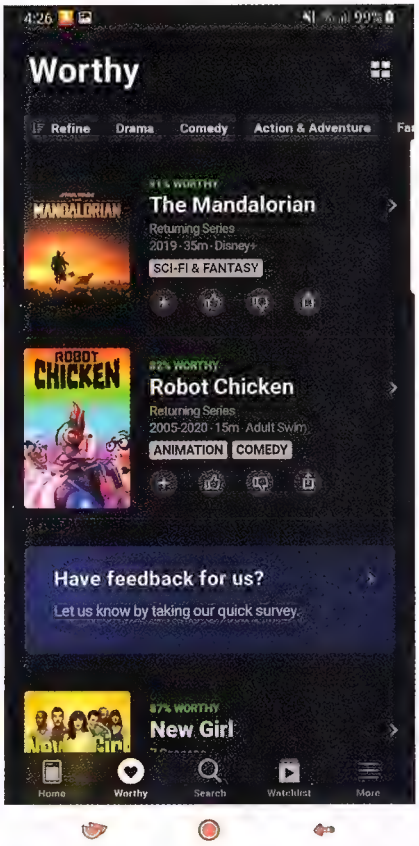
Android | Free

Access Dots

Sneaky apps.

Ever swear your apps have to be listening to you or even using your camera without your permission? Well there are settings in pretty much all phones to limit this but sometimes it can be pretty difficult to tell. That's where Access Dots comes in. This app will simply show you a dot on your screen whenever an app is using your camera or mic – much like iOS does natively. You can configure the colours and locations of these dots to stay out of your way or help catch your eye without paying a cent. Size and further customisations are behind a paywall but aren't necessary. There's even a log section which lets you see a history of apps accessing your mic and camera. This means if you don't happen to catch them in the act but suspect later, as long as the app is installed they should show up. Because of the relatively light functionality, Access Dots is presented minimalistically, which makes it easy to use while still looking clean.

★★★☆☆



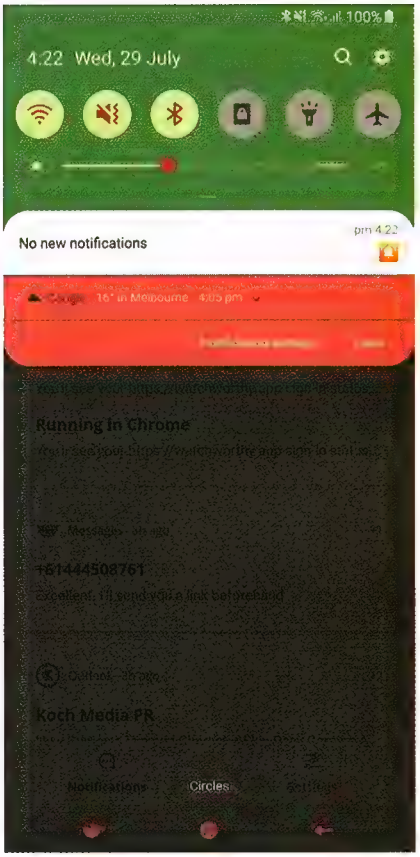
Android/iOS | Free

Watchworthy

Test worthy.

There's no denying that this pandemic has seen us all fly through TV shows like never before. Many services like Netflix will recommend content based on your current shows but if you're like me, you might be running a little dry. Watch Worthy aims to help you find your next binge by collating this information into a single app. It's certainly not the first app to try something like this, but it is one of the newest. Simply start by telling it shows you did or didn't like and you'll get recommendations in kind. There are even curated selections based on other parameters. At first it showed me things I'd expect, based on my previous ratings but it did eventually open up into some more obscure choices. It was refreshing to find shows I've never heard of in the mix, and to be reminded of old forgotten favourites. I would recommend turning notifications for this one off, unless you'd like to be constantly reminded it exists.

★★★☆☆



Android | Free

NotificationHistory

Ugly but interesting.

Another way to solve those notification woes is with an app, and one of the newest gaining traction is Notification History. It bundles your notifications into a separate app. They're still visible from the bar but potentially in less detail. What I like about the Notification History app is exactly that – it saves your history. There's a tab within the app that allows you to view past notifications already cleared. This is pretty handy if you're like me and a bit quick to clear without looking properly. You can even save particular notifications if you want to check in on them later. Lastly, groups are a handy tool. This allows me to put things like my six different messaging apps all under the one umbrella. However, I'm not sold on the presentation. Notification History ignores my theme and dark mode settings. It also insists on keeping the icon visible at the top of the screen, which is bright orange and visibly jarring. Much like my last date, it's just not nice enough looking to be a part of my every day.

HOPE CORRIGAN

★★☆☆☆

Robolinux 11

Review bot-at-large Jonni Bidwell does his damnedest to look past the late 90s-stylings of this project's website...

RoboLinux is a project that we've been meaning to look at for a while. It's a one-man effort, Ubuntu-based affair, but stands unique among its numerous peers. The project's website (which may have used WordArt for its logo, which of course is absolutely acceptable) carries the headline "Robolinux runs Windows XP, 7 & 10 Virus Free". A bold claim indeed, and perhaps one that needs some degree of qualification.

Its main feature is access to a one-click Windows XP or 7 installer, so that users can run their current Windows applications inside a virtual machine (VM). Keen readers will note that Windows XP and 7 are both now EOL (end of life) products, and are susceptible to all kinds of malware, VM or no. Granted, if that VM is sufficiently firewalled (or absolutely isolated from the internet in the case of XP) the risks can be diminished.

The trouble is, all that one click gets you access to is an invitation to make a donation (at least US$25) to the developer ("Robo") so that he can remote assist you into setting up a VM. We don't have $25, and nor did we really want to run any Windows tools. So we didn't test this. It all sounded a bit rough and ready (perhaps that's unfair, but it's certainly not a scalable solution). Be that as it may, the rest of the distro had some interesting features so we figured we'd persevere.

Straightforward installation

It's based on Ubuntu 18.04 (the release notes cite stability concerns with 20.04) and comes in Cinnamon, MATE and Xfce flavours. Installation requires a ludicrous 25GB, so we deleted a vast tranche of GIFs (farewell noble moieties of amusement) to make room. The 18.04 installer is changed in name alone, and as we've come to expect, proceeded without a hitch. The initial install occupied 16GB, and includes popular applications such as SimpleScreenRecorder and VLC. Having VirtualBox pre-installed is handy too, even if you're not going to make use of the guaranteed virus-free StealthVM hyper tech.

Windows are decorated with the Numix theme, which we like, but for some reason the desktop uses the long-abandoned BlackMATE theme. The worst part about this is the awful use of a serif font in the window list and tooltips. Also, it would have been nice to include a newer version of Cinnamon. It felt odd coming back to this one after our Mint 20 extravaganza.

Besides the paywalled VM option, Robolinux features its own Untracker application. This seems to be little more than a script to change your MAC address on every boot. We can't be sure because, again, it's paywalled. There are some poor taste jokes on the donation page about contact tracing, which made us dislike this even more. MAC addresses are used for routing at the link (i.e. Ethernet) level. They're not required by the IP layer on top of this, and so are stripped from IP packets sooner or later when they hit a router. Sometimes they're used to generate IPv6 addresses (although this method is falling out of favour), but to suggest they're used for tracking is largely scaremongering, and to try and get money for a script (which you can do in a Bash one-liner) is rather underhand.

Perhaps we're being unduly harsh. The paywalled tools were free until last year, Robo is clearly undergoing some financial hardships and we do sympathise with his plight. He offers unlimited free email support or paid for telephone support. Noble, but again, not scalable.
JONNI BIDWELL

The idea is not bad, but the execution – in particular the conspiratorial anti-MS sentiment which seems to motivate the project – is.
★★⯪☆☆

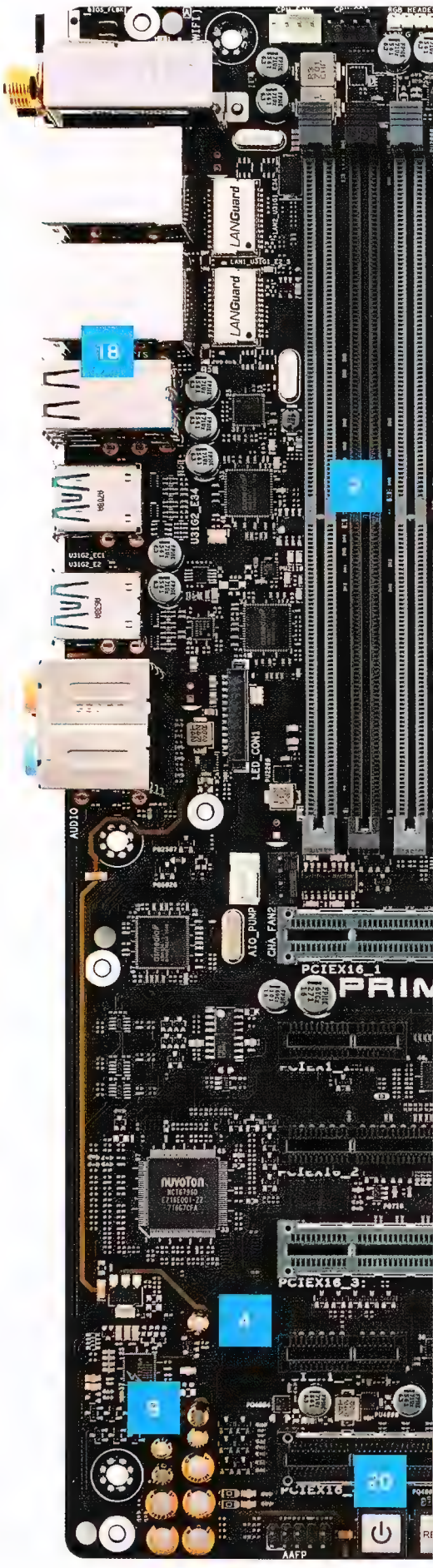
"'Robolinux runs Windows XP, 7 & 10 Virus Free'. A bold claim indeed, and perhaps one that needs some degree of qualification."

It's pretty much just Ubuntu 18.04 loaded with stuff that you don't need and some referral links. Oh, but that's a lovely jungle pic though.

LABS FEATURE

Anatomy of a motherboard

Gavin Bonshor breaks down just what makes your motherboard tick, in this primer on the computing world's most underlooked piece of tech.



Let's face it, much of the buzz surrounding product launches of new CPU architectures revolve around core count, thread count, clock speed, turbo clock speed, supported memory speeds – you name it. However, if the CPU is the engine of a system, then the motherboard is the manifold without which nothing would function.

With so many different key components that make up a computer system, the motherboard is the central hub that binds and connects the processor to the graphics card, memory, storage, and so on. Not only that, but it also connects a whole host of controllers from the motherboard chipset to the CPU, which essentially manifests into input and output, such as USB ports, audio jacks, M.2 slots, networking controllers like Ethernet and Wi-Fi, and even Thunderbolt 3 on premium models. At the launch of every new chipset, motherboard vendors release swathes of models, from the more budget-focused to the highly premium that are decked out with more features than you can shake a stick at.

The core fundamental aspects of a motherboard consist of much the same across all models, whether that's an AMD or Intel-based board, with each motherboard vendor implementing its own aesthetic and feature sets based on support from both the processor and the motherboard chipset.

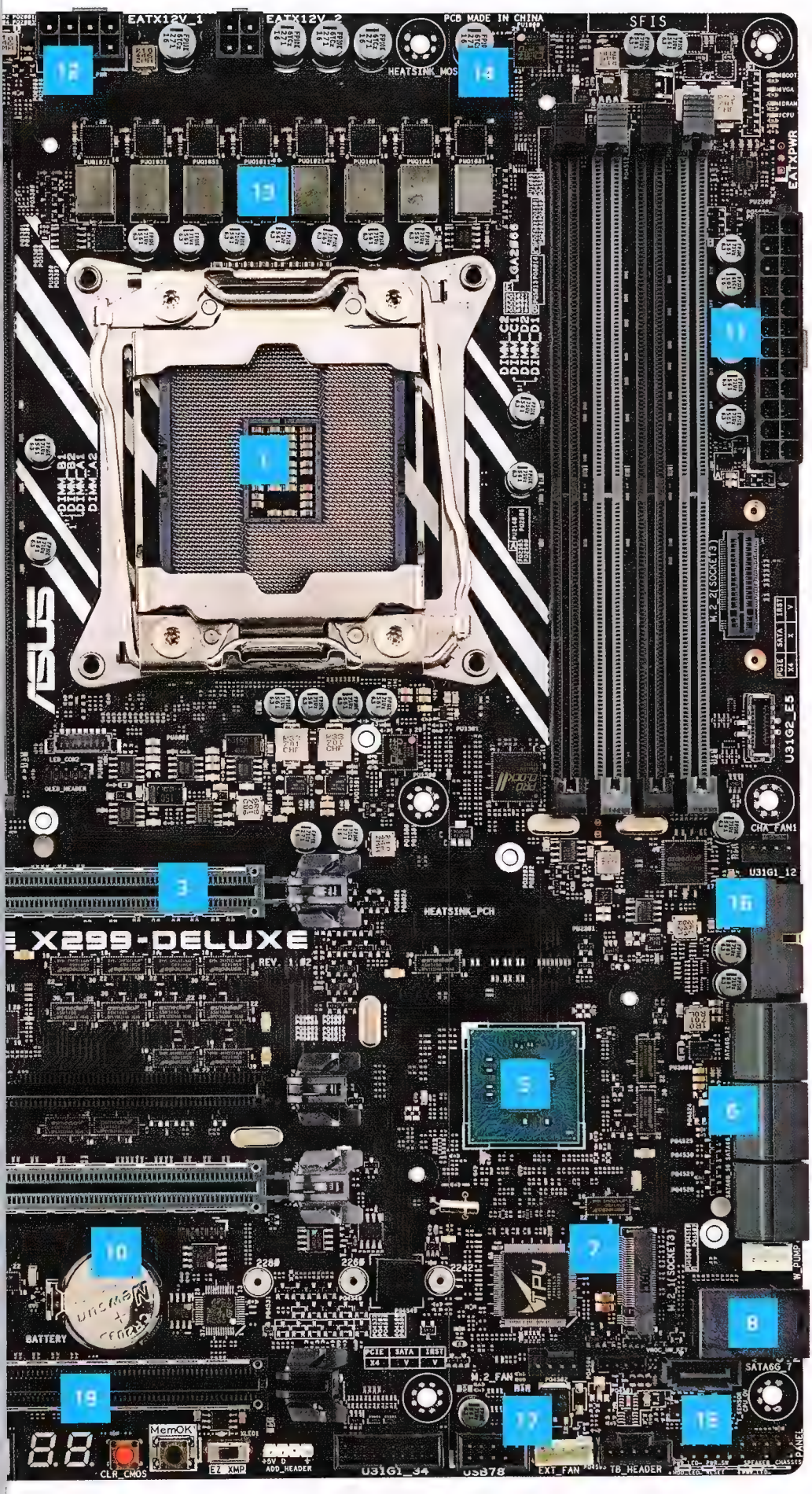
In this issue, we're going to take a journey through how a motherboard "works," what components make up a conventional consumer-level desktop motherboard, and why each component is important.

The modern motherboard: a basic diagram

One of our favorite quips within this industry is that "no motherboard is created equally," and although true to a certain degree, in this instance it doesn't have much swing. This is because each desktop motherboard has the same core characteristics that makes it a motherboard, and that remains the same across each platform regardless of processor, brand, or chipset model. Let's have a look at a typical motherboard and its most commonly associated and distinctive features.

Each motherboard will include a different feature set, and as a result will include different headers – some more and some less – especially when compared with the premium Asus Prime X299-Deluxe motherboard we've illustrated. This includes things like M.2 slots, with some models opting for one, and some even managing to include three or four. Parts including Power/Reset buttons and LED debuggers are more commonly found on premium models, and are omitted from a lot of budget-focused models primarily due to cost.

Now let's take a dive into some of the more intricate motherboard characteristics and commonly



Asus Prime X299-Deluxe motherboard

1 CPU socket
2 Memory slots
3 PCIe x16 slot
4 PCIe x1 slot
5 Chipset
6 SATA ports
7 M.2 slot
8 U.2 port
9 Audio codec
10 CMOS battery
11 Motherboard 12 V ATX power connector
12 CPU 12 V ATX power connector
13 Power delivery/VRM
14 Fan header
15 Front panel header
16 USB 3.x header
17 USB 2.x header
18 Rear panel I/O
19 LED debug
20 Power/Reset buttons

used terminology, and what it means.

Form factor: size matters

When it comes to motherboards and deciding which one is the right one for the job, the form factor is one of the most important aspects for a multitude of reasons. Firstly the form factor relates to the size of the motherboard, with the most common form factors consisting of ATX, micro-ATX and mini-ITX. Each includes its own set of characteristics, as the smaller the motherboard, the less that can be placed onto it. Technically speaking, a mini-ITX system will have a smaller desktop footprint than that of an ATX-sized PC, and will restrict things like memory capacity and expansion slot (PCIe) support. The dimensions of the three most common form factors are as follows:

- ATX – 305 x 244mm
- Micro-ATX – 244 x 244mm
- Mini-ITX – 170 x 170mm

Expansion slots: the TL:DR on PCIe

Related to sizing, each motherboard includes an array of expansion slots, with PCIe x16 slots or full-length slots for devices such as graphics cards, and PCIe x1 slots for things like network controllers, SATA controllers, and premium sound cards. Each motherboard chipset and CPU has a limited amount of PCIe and high-speed input and output (HSIO) lanes, which determine how many slots can be implemented and how they can be used. A common example of this is multi graphics card support, which will require two or more full-length PCIe slots, with AMD Crossfire two-way requiring a minimum of PCIe x4 to operate, and Nvidia SLI demanding at least PCIe x8. On more recent models, there is support for the PCIe 4.0 standard (here's looking at you AMD Ryzen 3000), which is the latest and greatest, but there is still little in the way of components on the market to fully utilise the extra bandwidth available. Most motherboards on the market include PCIe 3.0, although it is backwards compatible, meaning a PCIe 3.0 card could be placed into a PCIe 4.0 slot, but it would just operate at PCIe 3.0 speeds. Some older models and the cheapest of the cheap sometimes include PCI slots, which is an older standard and virtually non-existent in today's ever-evolving industry.

Expansion slot connection standards have been backwards compatible since PCIe 2.0.

Whether it's PGA or LGA, the CPUs effectively connect the same way.

CPU: socket LGA and PGA

One of, if not the most important trait of a motherboard is the CPU socket, as this is where the PC's brain and engine rests. For consumer models, there are two primary socket types: LGA, or land grid array; and PGA, also known as pin grid array. AMD has opted for a PGA socket that, when reverting to basics, means the pins are on the CPU, with pin slots in the socket; for example socket AM4. For as long as we've been using computers, Intel has used an LGA design, which means the pins are in the socket.

Regardless of whether or not the pins are in the CPU socket or on the CPU itself, these are very fragile, and one slight knock or slip can result in dead hardware. To make the installation of CPUs easier, Intel LGA sockets use a mechanism and latch to create compression force when installing it, with a notch to show which way the processor is installed. For AMD, there is a similar notch or arrow in one of the corners of the CPU, and it uses a handle to release and hold the CPU in place. It's worth noting that most manufacturers don't include installation socket damage in their warranty cover, so great care must always be taken when installing the CPU.

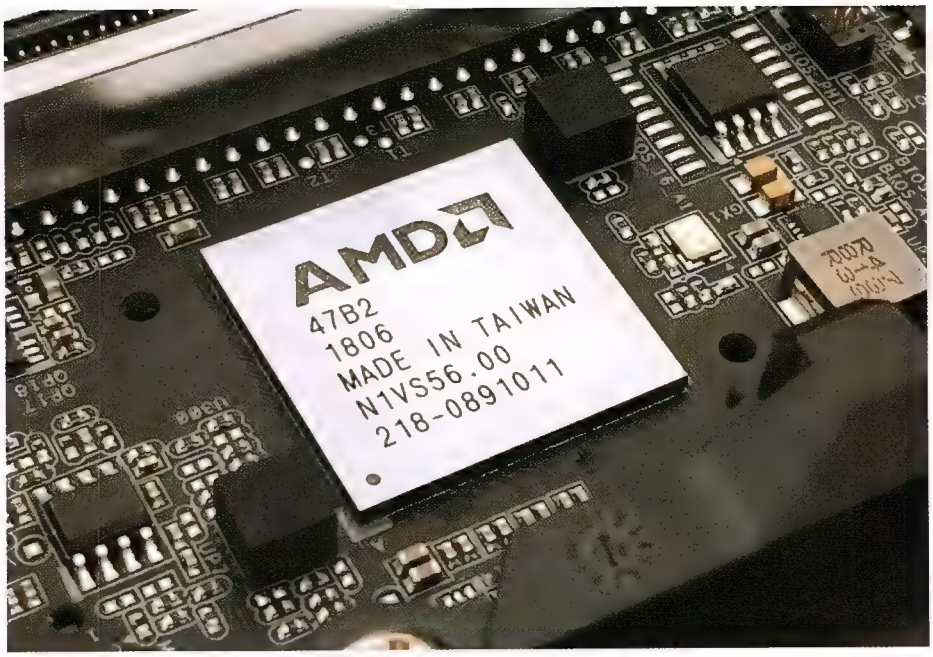
What is the chipset?

The second most important and functional part of a motherboard is the chipset. There are various chipset types, each with its own set of support, including PCIe, SATA, USB, and on newer chipsets, integrated networking PHY or a physical layer. The term chipset is a far-reaching term and in itself, acts as the adhesive and communication hub between the CPU and the motherboard's componentry, including slots, and input and output.

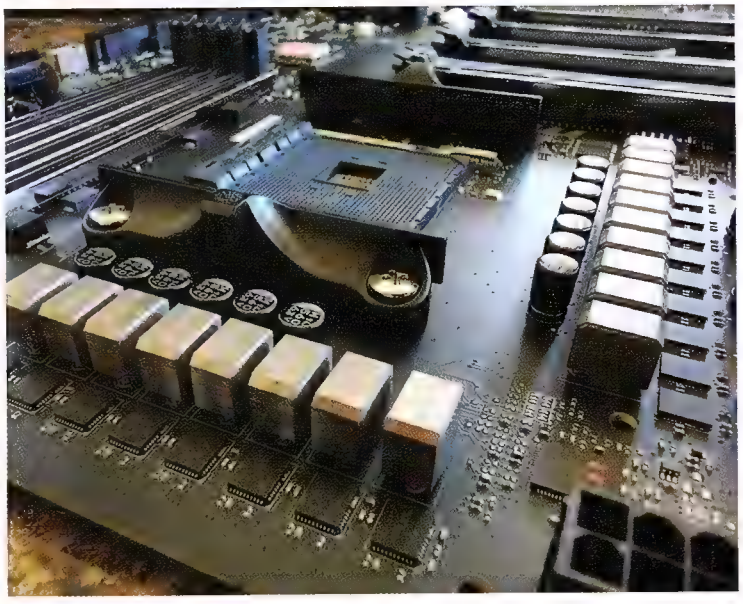
While the CPU is by far the most

influential common denominator in regards to overall system performance, it drives the PCIe x16 slot and – using the AMD Ryzen 3950X processor as an example – includes integrated PCIe 4.0 lanes. The latest performance chipset from AMD, the X570 chipset, includes PCIe 4.0 lanes within it, which enables users to benefit from PCIe Gen4 M.2 SSDs for trailblazing read and write performance. The most recent chipset from AMD is the B550 chipset, which is a watered-down and budget version of the X570 chipset, but instead of PCIe 4.0, it uses PCIe 3.0 in the chipset.

This is important to know. Generally speaking, the top full-length PCIe slot will always be driven by the PCIe lanes from the CPU, and on premium models, the second full-length slot too. This also includes the top M.2 connector, which is generally powered by the CPU too. Expansion slots, such as additional full-length PCIe slots outside of the top or top two, and PCIe x1 slots are all controlled from the chipset. The chipset also controls a motherboard's core SATA ports and additional M.2 slots.



The chipset is an important component, as it handles all the connectivity that the CPU doesn't.



In a VRM, the cylinders are the capacitors, the rectangles are the chokes, and the chips next to the chokes are the power stages or phases.

Chipset support: budget, performance and HEDT

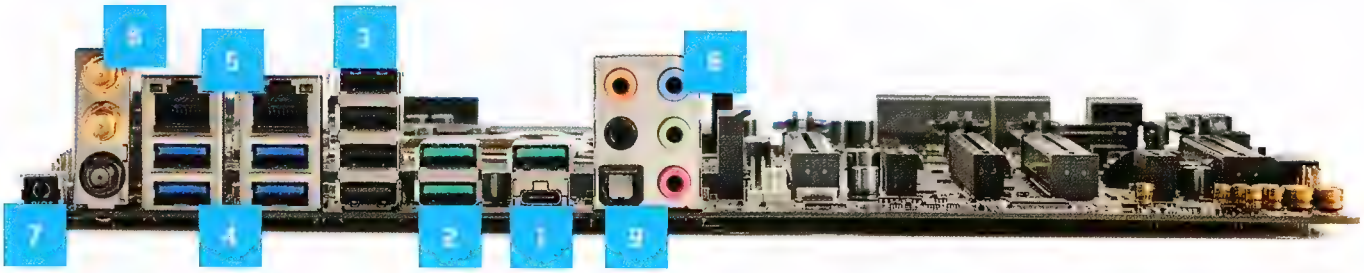
Another important thing to note is that some processors will only work with certain motherboard chipsets, even including those that feature the same socket type, for example Intel's LGA115x platforms. There are budget chipsets that generally begin with the letter A, B, and H, followed by the series, such as B360 for Intel's 9th-generation Coffee Lake processors, or A520 which is designed for AMD's Ryzen 3000 series and Athlon processors. Going even further into chipsets, there are the more premium variants, such as Intel's latest Z490 chipset for its 10th-generation Comet Lake, and AMD's latest X570 chipset, which generally speaking are both the flagship consumer chipsets for performance and premium features. These models for the most part include certain traits, such as four memory slots with support for dual-channel memory, premium integrated audio, and more USB support than most users will ever need.

The crème de la crème of motherboard chipsets are the high-end desktop models, or as they are commonly known, HEDT. These chipsets include Intel's X299 and AMD's TRX40, which offer superior memory and connectivity support, and are commonly used by content creators who demand high core-count processors for intensive workloads, such as video rendering, image manipulation, or for just pure E-peen. These typically include support for quad-channel RAM and support for higher capacity memory, and usually include up to eight memory slots, compared to four on even the most high-end consumer-based model.

Choosing the right chipset is important, and it goes hand in hand with CPU selection, as both need to support each other. Some chipsets even include active cooling solutions as they can run very hot, especially AMD's X570 chipset, which generally comes with a cooling fan integrated into the chipset heat sink. When buying a new motherboard, always check which chipset supports which CPU, as installing the wrong processor into the wrong motherboard can not only cause damage during installation, but can effectively kill hardware very quickly if not paired up properly.

The power delivery: VRMs and what they do

In recent years, a lot of focus on selecting a motherboard has been around the power delivery, or VRM



The rear panel I/O: input, output, throughput

The rear panel is essentially the input and output section of the motherboard, with plenty of different connector types featured depending on the motherboard itself. The most commonly found connectors include USB, RJ45/Ethernet, and 3.5mm audio jacks. Looking at USB, there are many different types, with motherboard vendors opting to colour-code them for easy identification, but this isn't a general rule of thumb. Black ports typically signify basic USB 2.0 ports, with deep blue often associated with USB 3.0 ports. Other colours generally indicate USB 3.2 or USB 3.1 connector types, but as mentioned, this varies on both vendor and model. There are also two types of USB interface found on modern motherboards, including Type-A and Type-C.

The difference between the different standards of USB, including 3.2, 3.1, and 2.0 is in the bandwidth support. USB 3.2 Gen2 typically supports up to 20Gbps or 10Gbps on the Type-C interface, while Type-A will usually support up to 10Gbps. To make it easier to understand, here's the details:

- USB 3.2 Gen2 x2 Type-C = 20Gbps
- USB 3.2 Gen1 Type-C = 10Gbps
- USB 3.2 Gen2 Type-A = 10Gbps
- USB 3.2 Gen1 Type-A = 5Gbps
- USB 2.0 = 480Mbps

On premium models, motherboard manufacturers add Intel Thunderbolt 3 controllers, which use USB 3.2 Gen2 Type-C connectivity, combined with DisplayPort video inputs to leverage the technology to the full and reap the benefits of enhanced bandwidth.

1 USB 3.2/3.1 Type-C
2 USB 3.2/3.1 Type-A
3 USB 2.0 Type-A
4 USB 3.1/3.0 Type-A
5 RJ45/Ethernet
6 Wi-Fi 5/6
7 BIOS flashback button
8 3.5mm audio jack
9 S/PDIF optical output

as it's commonly known. The term VRM stands for voltage regulation module, and a basic definition of what it does includes controlling the power to the CPU as well, as the system on a chip–or SoC – which is commonly used by processors with integrated graphics. It also converts the power down from the 12V rail on the motherboard – through the 12V ATX power inputs – to a workable DC voltage, as the VRM also acts as a buck, which converts DC to DC power. This conversion is important as it enables the CPU to operate with sustainable voltages, which, if it wasn't converted, would blow the processor pretty much instantly.

A basic example of how a VRM works is as follows. It starts by pulling power from the 12V rail from the power supply into the power delivery or VRM. The VRM then converts this 12V power into a lower voltage so the processor can use it, and it also regulates it so that it stays well within the operating voltage that the CPU requires to work. Even with overclocking the processor, CPU core voltage is typically kept under 1.4V, which in itself is around an 88% reduction in the voltage drawn from the power supply compared to what the CPU is actually using.

Another variable to consider when looking at a motherboard's VRM is its capabilities in relation to maximum supported current. This is especially important when overclocking the processor, as some power deliveries aren't designed for thunderous power loads, although motherboards in recent times are more than well-enough equipped. The configuration of the power delivery is also important, as one of the biggest grumbles is assuming a higher number of power stages or phases mean it has a better VRM. This is a gray area with some vendors in regards to marketing and advertisement, as a six-phase CPU VRM with six 90A power stages can deliver a maximum current of up to 540 amps, where an eight-phase CPU VRM with eight 60A power stages equates to a maximum current of 480 amps.

Some motherboard manufacturers use different types of configuration, with some offering direct phase designs that work in a one-to-one method, with one channel operating one phase from the PWM (pulse-width modulation) controller, which drives and controls the power delivery. Some opt for the use of doublers, which work with two phases operating from one channel. Asus has switched to "teaming" its phases in pairs, which is designed to deliver higher levels of burst current while maintaining efficiency, in regards to computational and thermal performance.

The benefit of more phases is generally associated with better reliability and can have a positive effect on operating temperatures, as usually the VRM is cooled by a simple heat sink. Some enthusiast-grade models incorporate active designs with small cooling fans, with the most premium including VRM water blocks, such as the Asus ROG Formula series.

Networking & audio

For networking, some boards use a single RJ45 connector, while others use two for superior connectivity. The general shift in recent months has gone from 1 Gigabit to 2.5 Gigabit Ethernet ports, which motherboard vendors are looking to use, as the new go-to technology as the industry quickly moves far and beyond standard Gigabit. This also includes Wi-Fi, with a big

transition occurring this year from Wi-Fi 5 (802.11ac) to the better Wi-Fi 6 (802.11ax) standard. This is good for gamers who demand a solid connection during online gameplay but don't necessarily have the scope or capability to use wired Ethernet, which is almost always the best connection standard for performance and network stability.

Other areas to consider include onboard audio, which usually comes with different inputs and outputs depending on the grade of audio codec that each model is using. More premium codecs, such as the Realtek ALC1220, feature five 3.5mm audio jacks and a single S/PDIF optical output, while lesser codecs like the Realtek ALC892/887 can consist of just three 3.5 mm audio jacks. This is something to factor in when purchasing, or you could use a PCIe lane or USB port and opt for a higher quality audio interface altogether at an additional cost. Some models also include PS/2 ports, which allow the use of older and more legacy peripherals, including keyboards and mice.

PCI Express x16, x4, x1, and PCIe 3.0/4.0

The term PCIe stands for PCI Express, with PCI itself abbreviated from peripheral component interconnect, which is an interface standard. This enables users to connect extra components to a system, including graphics cards. This also includes aftermarket sound cards, additional networking controllers, and even RAID cards for storage-savvy power users.

At present, there are two primary interface standards for this type of connector: PCIe 3.0 and PCIe 4.0. The maximum theoretical bandwidth of PCIe 3.0 equates to 32GB/s, with a frequency of 8.0GHz, while PCIe 4.0 doubles these figures to 64GBps and 16.0GHz. The benefits of PCIe 4.0 at the current time are limited, not by the technology itself, but by the shortage of devices that are PCIe 4.0 enabled to make use of this extra bandwidth.

One important point to note is that in multi graphics card configurations, such as AMD CrossFire and Nvidia SLI setups, to run more than one Nvidia GeForce graphics card in SLI, a full-length PCIe 3.0 slot that operates at a minimum of x8 is required, and even some chipsets such as AMD's B550 just don't have the capability to do this. For AMD CrossFire setups, a PCIe 3.0 x4 full-length slot is needed, which is usually operated from the chipset.

In regards to size, PCIe 3.0 and PCIe 4.0 x16, x8, and x4 slots are generally always either full-length or half-length on some models, with x1 slots the smallest of all. The type of slot needed for the type of expansion card usually comes down to what interface the card supports.

The only area that currently shows a real-world benefit comes through storage, and even genuine PCIe 4.0 drives are hard to source. One example is M.2 SSDs with PCIe Gen4 controllers and one of the most commonly used NVMe controllers from Phison, the E16 to be exact. This is identical to the Phison E13 controller bar PCIe 4.0 supports, which does give it an advantage over PCIe 3.0 M.2 SSDs, but not enough to saturate the bandwidth to its fullest capabilities. Phison has announced and previewed its E18 controller based on a 12 nm FFC process, which looks to further enhance the PCIe 4.0 interface.

Storage: M.2 to U.2, with some SATA on the side

Storage is an equally important part when considering your new motherboard, whether that's a gaming system, something more for conventional office use, or even a megalithic rendering PC for content creation. For consumer desktop motherboards, there are three main types to consider, which boils down to two things: support from the CPU, and support from the chipset.

The SATA or Serial ATA connector has been the standard interface for storage for many years, which is a rectangle-shaped connector that is usually found in two flavours: right-angled and straight-angled format. This is the most commonly used storage interface, with support in regards to RAID arrays dependent on the motherboard chipset used. Intel typically supports RAID 0, 1, 5, and 10 arrays, while AMD only offers support for RAID 0, 1, and 10 officially on its desktop models.

The most common type of premium storage found on motherboards is M.2, with different types, such as the conventional SATA-based M.2 SSDs, or the intergalactic NVMe super-speed drives that operate from PCIe 3.0/4.0 x4/x2 slots. When upgrading a PC, one of the areas where users can see the biggest possible gain in real-world scenarios is going from a SATA 3.5-inch hard drive to a SATA 2.5-inch SSD; the difference in loading times is mind-blowing.

The M.2 interface further improves on this, but with a little bit of diminishing returns due to bandwidth.

But in regards to transfer speeds, PCIe 4.0 x4 M.2 drives do it best, with crazy speeds, bearing

U.2 may have been quick, but M.2's compatibility proved king in the end.

in mind the limitation is the read and write speeds on the slowest drive in the transfer itself.

Another PCIe-based storage interface is U.2, which is similar to M.2 in many ways and shares similar support for PCIe, meaning more bandwidth and ultimately more performance. The biggest difference between M.2 and U.2 – aside from the shape of the connector, U.2 being a square shape and M.2 being small and flat – is that U.2 simply supports higher capacities of SSD, which is typically found on more professional-focused motherboards.

That being said, M.2 drive capacities are starting to increase, and U.2 doesn't seem to have the buzz it once had. The M.2 form factor drives are also considerably cheaper, so it makes selecting one of the many M.2 drives on the market a no-brainer.

Now you've met the motherboard – what are the options?

Despite there being various differences in Intel and AMD's CPU architecture and design, each corresponding socket release yields a new chipset, and thus offers a completely different feature set. The current generation of motherboards include a variety of different characteristics, including USB 3.2 G2 connectivity, with Thunderbolt 3 offering the most comprehensive and exclusive of all the connectors, though this is usually found on more premium models.

Finishing off our little biography is a table of current motherboard chipsets from Intel and AMD (within the last two years), which CPU architectures are supported, and what market they are aimed at. This journalist regularly overviews chipsets at launch, as well as in-depth motherboard reviews over at AnandTech (**www.anandtech.com**), so for more definitive guides on each chipset, feel free to check them out.

A chipset is not only part of the overall engine, but it's the gateway between the processor and all of the board-integral componentry. One of the most important things to consider when building a new PC or graphics card-laden system is ensuring the processor and the chipset provide adequate features to fit the bill.

Leaving the more prosumer chipsets out of the equation. There are notable differences between the HEDT chipsets, such as Intel's X299, and its desktop Z490 chipset. The biggest difference is that both AMD's and Intel's current HEDT platforms support quad-channel memory, while the non-HEDT enthusiast, budget, performance, and mainstream chipsets include support for dual-channel DDR4. ■

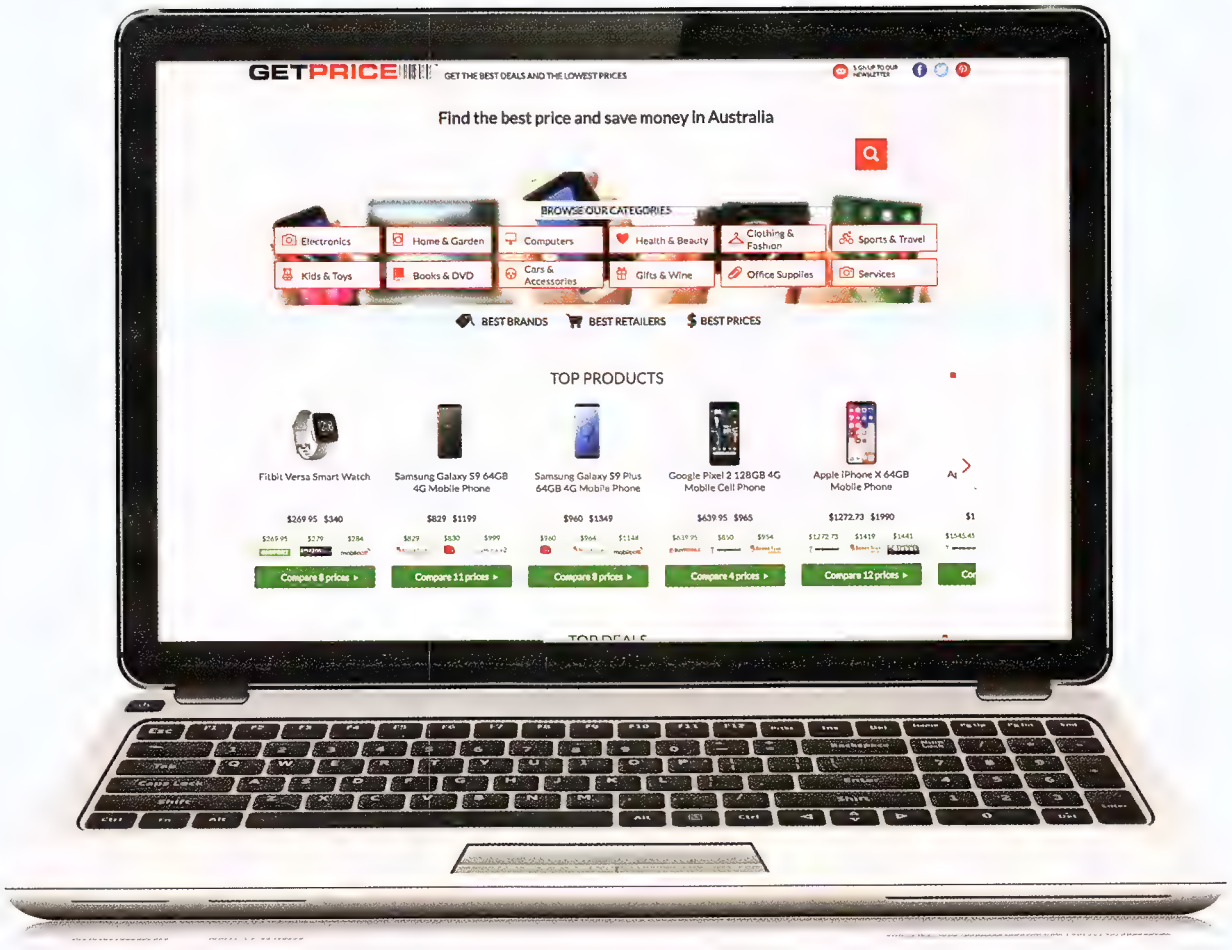
Modern chipset specifications

AMD CHIPSETS

	Target market	CPU socket	Official CPU support	PCIe interface	Memory channels	Overclocking support?
TRX40	HEDT/Enthusiast	sTRX4	Threadripper 3000	PCIe 4.0	Quad	Yes
X570	Enthusiast	AM4	Ryzen 3000/2000	PCIe 4.0	Dual	Yes
B550	Budget/Performance	AM4	Ryzen 3000	PCIe 4.0/3.0	Dual	Yes
A520	Budget/Mainstream	AM4	Ryzen 3000	PCIe 3.0	Dual	No
X399	HEDT/Enthusiast	sTR4	Threadripper 2000/1000	PCIe 3.0	Quad	Yes
B450	Budget/Performance	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
X470	Enthusiast	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
B350	Budget	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
X370	Enthusiast	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
A320	Budget/Mainstream	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	No

INTEL CHIPSETS

	Target market	CPU socket	Official CPU support	PCIe interface	Memory channels	Overclocking support?
X299	HEDT/Enthusiast	LGA 2066	Cascade Lake-X/Skylake-X	PCIe 3.0	Quad	Yes
W480	Workstation/Professional	LGA 1200	Comet Lake/Xeon W-1200	PCIe 3.0	Dual	No
Z490	Enthusiast	LGA 1200	Comet Lake	PCIe 3.0	Dual	Yes
H470	Budget/Mainstream	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
H410	Budget/Mainstream	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
B460	Budget/Performance	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
Z390	Enthusiast	LGA 1151	Coffee Lake	PCIe 3.0	Dual	Yes
Z370	Enthusiast	LGA 1151	Coffee Lake	PCIe 3.0	Dual	Yes
B360	Budget/Performance	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
Q370	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
H370	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
H310	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
Z270	Enthusiast	LGA 1151	Kaby Lake/Skylake	PCIe 3.0	Dual	Yes



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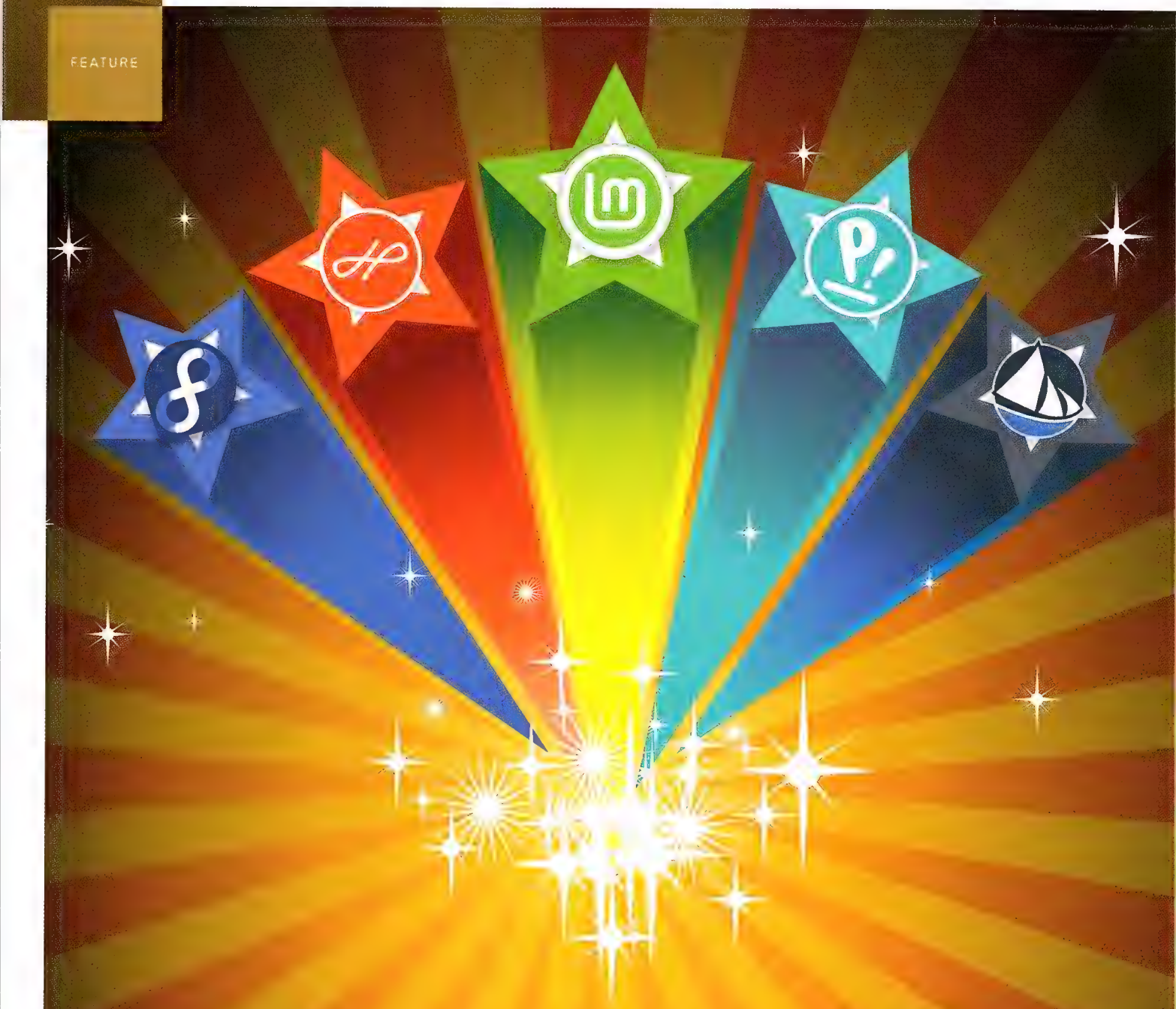


Next-gen distros

Step right up! Jonni Bidwell is here to unveil the finest Linux distros around!

Cast your mind back 15 years, to that pre-credit crunch optimism of the mid-2000s. Windows users were appalled by Windows Vista, and this new Ubuntu operating system was claiming that it could displace Windows. This, despite being based on Linux and thinking that orangey-brown hue was a good desktop colour.

Well, Windows may not have been wiped out by Ubuntu. But Linux has developed in leaps and bounds. It's more useable than ever and key industry players take it much more seriously now. Thanks to Valve and Vulkan, we can play thousands of Windows-only titles on our Linux boxes. More companies than ever are shipping Linux on consumer hardware. Your wireless hardware probably works with it.

Best of all, there's a fine range of distros to choose from. Ubuntu has always been a great place to start, but it's not to everyone's taste. Here, we present our pick of the next generation of distros, sure to ruffle a few feathers. Since making Linux easy is very difficult, we've got a section on useable distros, including our long-time favourite for beginners: Linux Mint.

Next, we'll explore some of the best-looking distros out there that will give you a truly modern desktop. In particular elementary OS, through its Pantheon desktop, is doing the unthinkable by making Linux simple, powerful, and – dare we say – at least a little bit Mac OS-like.

Finally, we'll look at distros that are leveraging the latest in open source technologies. You might not want these technologies (or so it seems by the number of complaints we get about Wayland, Systemd et al.). Or you might not be able to use your favourite software with them easily, but these will shape desktop Linux in the years to come.

Linux milestones

Many battles were fought – and coffee urns emptied – to get distros to where they are today. Here's a quick recap...

Linux distributions have come a long way since the good old days. In the beginning, of course, there were no distros. You'd start with the kernel, somehow bootstrap a barebones system, fetch some GNU tools, mess with the make files, compile those packages, install them, realise you'd got your Makefile wrong, tidy up the mess. Rinse, lather, repeat. It was all great fun.

More often than not you had to get these things on CD or even floppy disk in the post, unless you had access to the internet (or a friend in a computer science department). Then in 1992 came SLS, which inspired Slackware and later frustrated Ian Murdock into creating Debian. Yggdrasil, the first Linux live CD, was launched shortly after SLS, which required a gluttonous 8MB of memory and a gargantuan 100MB of disk space. The first stable version of Debian didn't appear until 1996, by which time Red Hat Linux was on the scene and all of a sudden people realised there was money to be made with that thar Linux.

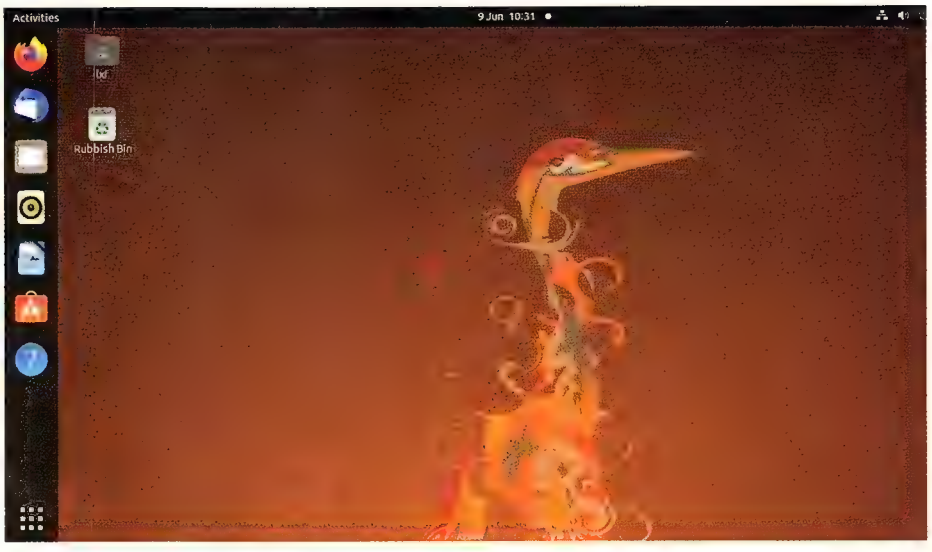
It's easy to overlook the contributions of those pioneer distributions, and other giants such as SUSE and Mandrake. And indeed those of lesser-heard ones such as Conectiva (a distant ancestor of Mageia that popularised Linux in South America). There's a tendency to just focus on Ubuntu as the great humaniser of Linux.

By the same token, there's a tendency to dismiss desktop Ubuntu today as a sideshow to Canonical's commercial success. Ubuntu continues to do great things for Linux, and is an excellent distribution for beginners and professionals alike. But what happened in the mid-2000s was pretty exciting. Suddenly, here was Linux that anyone could use. It did everything that Windows XP did (except maybe talk to your wireless device). There was an office suite that could mostly open Word documents. Finally, something was standing up to the Microsoft juggernaut...

Things are different now. Microsoft's attitude towards open source has changed and desktop computing isn't the be-all and end-all it once was. The web is truly OS-agnostic, so there's no danger of say, your bank not supporting you if you use Linux. We take for granted the ability to watch Netflix or play games, but this would have been unimaginable just a few years ago. Today Intel, Oracle and even Microsoft (sort of) now have their own Linux offerings. A few stand-out distros have emerged that have brought genuine innovation, whether technical or ideological, to the Linux world. So let's have a look at some of them...

Changing times

"Today Intel, Oracle and even Microsoft (sort of) now have their own Linux offerings."



The Hardy Heron wallpaper (from 2008) was remastered for Ubuntu 20.04.

Solving problems

Don't worry if you think something's not right with a particular Linux distribution. You're entitled to a full refund after all. Only kidding. In 2012 even Linus himself raged at OpenSUSE developers when he discovered that adding a printer (on his daughter's laptop) required the root password. Sometimes there are reasons why things are that way (in 2012 there wasn't the notion of a privileged local user; it's handled by systemd these days), sometimes it's a genuine bug, and sometimes you're just using it wrong.

These days Linus is generally calmer (except perhaps on the subject of L1D cache flushing), and his recently purchased development machine (a Threadripper 3970X which you can read all about on ZDNet at **www.zdnet.com/article/look-whats-inside-linus-torvalds-latest-linux-development-pc**) runs Fedora 32. And we'll talk about that later on. We'll also see how elementary OS is tackling unnecessary password requests over the page.

There are plenty of ways to get help with Linux, and thanks to its popularity it's highly likely someone has encountered your issue before you did. So your first act should be to always be to Google your problem. Beyond that, head to your distro's forums and search there. If you still feel like you've hit a new issue then describe it as best you can, and check the forum's guidelines about how to get and attach appropriate log files and hardware information. Help the community help you.

User-friendly usability

Some Linux distributions go out of their way to make new users feel comfortable. We shine a spotlight on those welcoming distros.

Let's look at Linux Mint first, which continues to be a favourite of ours. In particular, it's one that we still recommend to users who are taking their first steps with Linux. Initially (the 1.0 release in 2006 was a beta based on Kubuntu), it took the Ubuntu codebase and bundled flash and Wi-Fi firmware to make for a better out-of-the-box experience. It experimented with its own codebase for a couple of years, but then returned to Ubuntu's and since then the two have always been package-compatible. It enables Mint to piggy-back off the treasure trove of packages in the Ubuntu repositories, while still providing its own experience.

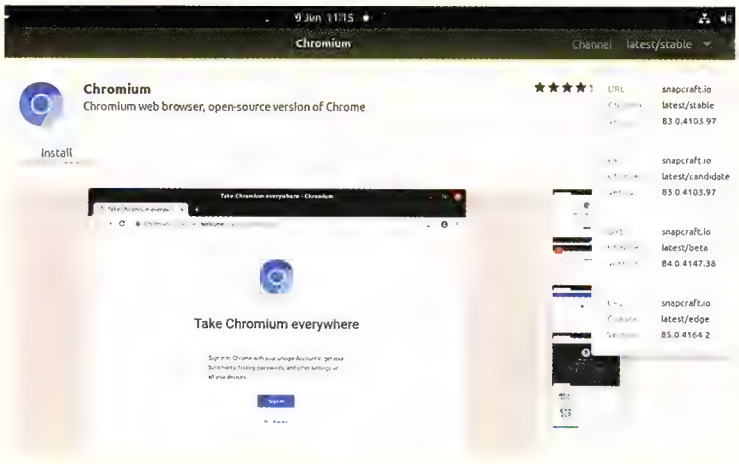
When Ubuntu switched to its Unity desktop, Mint offered something more conventional in the form of its Cinnamon desktop (which first appeared in Mint 13). Cinnamon was initially based on Gnome 3, but soon became its own thing. For die-hard traditionalists, they also offered the then-fledgling MATE desktop a fork of Gnome 2. Both Cinnamon and Mate continue to thrive, while Unity has been abandoned by Canonical (though the latest version lives on in the UBPorts mobile OS, and the penultimate edition is still tended to by a small but loyal community). When Ubuntu 18.04 was released, sans 32-bit ISO, Mint went ahead and produced its own (32-bit packages were still built for 18.04, this is not the case for the latest edition, so Mint 20 is 64-bit only).

We're still waiting for Mint 20 to arrive and Clem and the team have remained largely schtum about what to expect. In previous releases, it's been as much about what they've removed from Ubuntu as what they've added. For example, the 'anonymous' telemetry information that you have to opt out of sending in Ubuntu is banished from Mint.

As Ubuntu moved towards the Snap packaging format, some Mint users voiced concern about whether these would become the norm in Mint, too. They (unlike Flatpaks and AppImages) rely on a proprietary app store after all, which makes Canonical a sort of kingpin in the software distribution ring. The team reassured users that Mint wouldn't contribute to this Snap monopoly. Last year they said they'd support Snaps as long as they were useful, and "didn't become the de facto standard [for packages]". Now they've put their money where their mouth is. Try installing Chromium with apt in Ubuntu 20.04 and you'll find you get a dummy packages that installs the Snap version. This is irrefutable evidence of a Snap usurping a traditional package, and something the Mint team won't stand for.

Mint 20 beta insights

As we write this, the first details of what to expect in the Mint 20 beta are starting to emerge. And one of the first is that no Snaps will be installed by default. The snapd daemon will also be absent, but you can add it if you wish. As a precaution, traditional apt packages will be blocked from installing snapd, to prevent them acting, like Chromium's, duplicitously.



Chromium is only available as a Snap in Ubuntu. If you want it in Mint 20 then you'll have to fetch it manually.

Linux Mint made waves by giving users what they want. It sounds harsh and there are all kinds of complexities behind this, but other distros seemed reluctant to listen to their users. Alas, the most common gripe "why can't it just work?" is alive and well today (though this applies to other OSes and in fact all forms of technology). A sad trend that Ubuntu's accessibility inadvertently started was frankly unqualified users taking to bug trackers and venting their rage. People would describe their problems (badly) in angry block capitals, they wouldn't supply log files or hardware information, they wouldn't attempt to pin down the problem, they would fail to do even the most cursory search for other people having similar problems or, worse, they would jump on to similar bug reports crying "me too!" – even though their issue was different.

Developers shied away from engaging with such reports. The canned response thanking these newcomers for their submission and referring to reporting guidelines has become ubiquitous. One place Linux Mint excelled was through its community helping each other, and developers engaging with that community rather than being bothered by them. Their "Newbie Questions" forum still bears the tagline "all gurus once were newbies" and is still for the most part free of more experienced users being condescending to newcomers' questions. Even where those newcomers didn't read their helpful guide on how to ask for help.

Endlessly useable

Over the past decade some Linux distributions have appeared that go out of their way to be more useable (and less breakable) by regular humans. One such is EndlessOS. Originally tied to Endless Computers' hardware

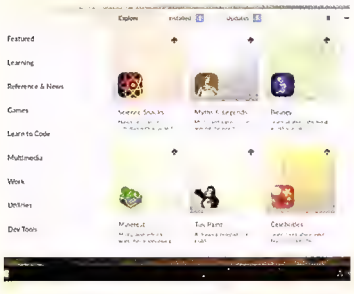
Next-gen app distribution

Flatpaks, Snaps, AppImages: they all seek to make it easier for developers to ship software in a distribution-agnostic manner. Whereas Snaps rely on a central app store, anyone can set up their own Flatpak remote. The Flathub repo (**https://flathub.org**) is a good place to find popular apps. Flatpaks are OSTree images too, which is why the two integrate so nicely in Endless OS. When you download your first (non-trivial) application on Endless OS (or your first Flatpak on another OS), you'll find the download is very large. This is because it depends on a large runtime (e.g. Gnome) Flatpak. Once you have this you won't need to download it again for Flatpaks which depend on it. These runtime Flatpaks are updated incrementally, so subsequent large downloads should be a rarity and (unlike deb packages) there are no issues with requiring a particular version.

Fedora's Silverblue desktop distribution brings atomic upgrades to the Fedora ecosystem. Here, a hybrid packaging system, RPM-OSTree, is used so that the base OS image can be modified in layers. This is useful for installing low-level packages such as drivers and shells. Conventional desktop programs are installed this way, and there's also support for containerised workloads.

The Future Of Apps On Linux
Flatpak is a next-generation technology for building and distributing desktop applications on Linux

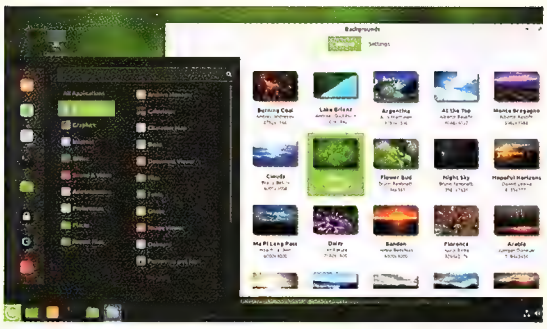
(budget small form-factor PCs aimed at developing countries), the Debian based distro is now available to all and comes in a few forms. The full desktop edition (available in seven languages) is a whopping 16GB in size, but includes the full text of Wikipedia, several Khan academy lectures and Endless' own educational tools. It's aimed at offline, and even off-grid usage. There's a more conventional desktop version (only 3GB), a VirtualBox image and finally an image for the Raspberry Pi 4. Besides their hardware (including the Spark kids' laptop) their educational contributions (such as their immersive Terminal Two coding tutorials, see **https://terminaltwo.com**), Endless has taken a particularly innovative approach to system updates.



Learn about history, science and, er, celebrities with Endless OS. The possibilities are, well, endless.

Such updates are a necessary inconvenience, but Microsoft has unfortunately turned a lot of people against them. Most egregiously when it force-updated thousands of Windows 7 machines to Windows 10, in many cases breaking them. But also, unless you tell Windows 10 to do otherwise, it has a habit of forcefully installing large updates at shutdown time (no good if your computer is in the same room you sleep in) or at boot time (no good if you actually wanted to use your computer when you turned it on). Another sad situation is when disk space is low, large updates will download and not be able to install. In some cases (particularly cheap tablets) this can make them entirely unbootable.

Linux updates tend not to be so disruptive, but they do on occasion break things. This is particularly upsetting for new users, especially if they're confronted with a confusing error message and a busybox shell or worse, a blank screen. It's easy to blame these issues on user error, or the Nvidia driver, but people shouldn't have to learn all about chrooting and modifying system files just to get their desktops back.



Mint gives users what they want: a traditional menu in the corner, a powerful file manager and beautiful desktop backgrounds.

Linux Mint conceded this, and that's why it launched its Timeshift tool for rolling back updates. Endless OS goes one step further: The whole filesystem is updated at once. This so-called atomic upgrade uses OSTree, itself described as "Git for filesystems" (or in this case operating systems). Of course, this doesn't mean every Endless OS device ends up with exactly the same filesystem (that wouldn't work unless every device was identical, hardware and software-wise). Rather, configuration files (say, everything in /boot and /etc) are layered atop the base OSTree image, and individual applications are installed as Flatpaks. You can roll back the entire OS to a previous version of the OS (just like you can switch Git branches) at the press of a button.

While the underlying OS is based on Debian, you can't readily use apt and .deb packages (or any traditional packaging format) on Endless OS. The OSTree/Flatpak combination makes for a bulletproof platform because the root filesystem is read only. Even if the power goes out mid-upgrade, the previous incarnation of the OS will still be accessible and the upgrade can be resumed. Installing an application won't break the base image because Flatpaks are self-contained. OSTree images are incremental too (only changes between versions are stored) and so the ability to roll back to a previous version doesn't come with a huge disk space cost.

The new generation

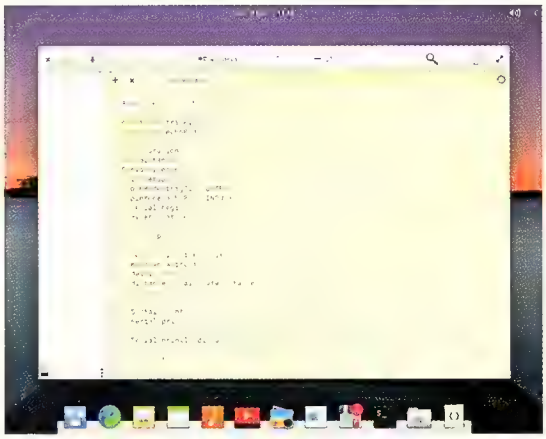
Check out these wonderfully crafted distros that give the operating system from a certain fruit-named company a run for its money.

Ubuntu-derivatives are a dime a dozen. Some you could probably recreate yourself by installing a desktop and changing some default applications. But some are simply outstanding, taking the rock solid Ubuntu base and adding unique and powerful features atop of it.

One such is elementary OS which, through its own Pantheon desktop, brings a sleekness and simplicity that rivals Mac OS. Instead of forcing users to read manuals (which in many cases just raises more questions), one of elementary's aims is to have minimal documentation. It aims to be sufficiently intuitive that users should be able to figure things out for themselves. Another of its design aims is "concision", keeping things simple and avoiding bloat. Finally, it strives for "accessible configuration": not bombarding the user with options, or asking for information that could be obtained automatically. This all might sound like fluffy design speak, but when you see how the app indicators convey with subtlety useful information, how the infobars gently notify you of exigent situations and how everything integrates so nicely (like a new-age type wittering on about how "it's all one, brah"), then you'll see there's substance to it all.

Contributing to elementary OS

Elementary OS is not free as in beer. It uses a pay-what-you-want model and when you download it you're asked to make a contribution. Ubuntu and some others use this model too, and nothing bad happens if you select $0. There's nothing inherently wrong with charging money for software – even free (as in speech) software. It's even expressly permitted by the GPL. Elementary, in asking for donations rather than slapping on a price tag, is striking a balance. It's ensuring that people get reimbursed for their work, while at the same time making it available to all. If you disagree with that stance then you're under no obligation to use it. If you want to contribute in another way, you can help fix bugs or help users on the forum (as you can for any software). There's even a bug bounty program, so if you're willing to pay for a feature (or would like to get paid for fixing something), then subject to team approval and someone coding it, you can.



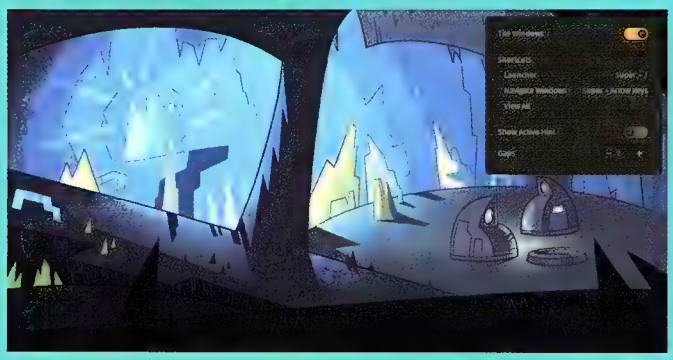
Code, elementary OS's text editor, is beautifully crafted. We can't guarantee our Arduino code is likewise.

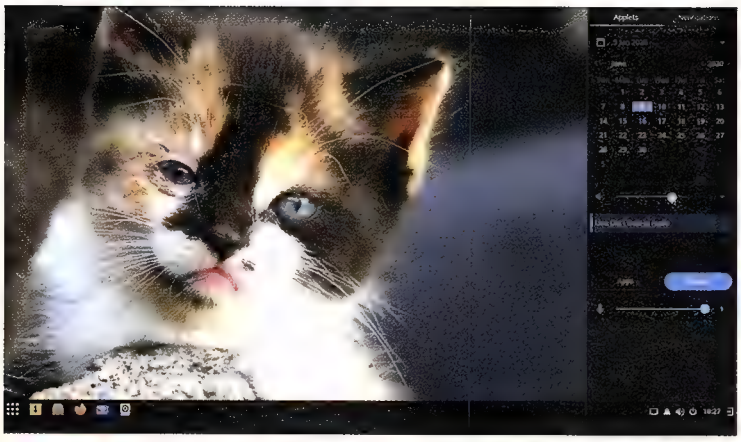
Fiscal models aside, elementary OS is beautiful. The Plank dock gives easy access to commonly used applications, and the bundled ones all follow a uniform design. They're all coded in Vala, which makes them integrate easily with GTK (or elementary's custom superset of it, dubbed Granite). They're free of unnecessary configuration options, proving that sane defaults are possible. Most interestingly, many of them don't have an explicit Save option. They'll save as you go and reopen to the same state they were left. The AppCenter (sic) includes a section of curated programs (that adhere to elementary's design philosophy and have been reviewed by the team) as well as everything you'd find in Ubuntu's

Behold, the gorgeous Pop!_OS

It would be remiss of us not to mention, in a spread about beautiful distros, Pop!_OS. We were thoroughly impressed by the 20.04 release back in April. Pop (we like most everything about it bar the awkward punctuation) is made by Colorado-based Linux system manufacturer System76. Being an OEM, they wanted to be able to ship an OS guaranteed to work with their hardware. But also, just like the other distros named in these pages, an OS that makes it easy for users to do whatever they want to do. Pop's desktop is much closer to Gnome 3 than what Mint, elementary and Solus offer, but don't be afraid. Don't also be afraid that the latest release gives you the option to experience (in a very gentle way) the joys of a tiling window manager.

Pop!_OS ships two editions, one featuring the Nvidia proprietary graphics driver and one featuring open source drivers for AMD and Intel hardware. System76 have contributed an awful lot to Linux including a Firmware Manager front-end for updating firmware via Fwupd. In Pop, this is integrated into the update tab in the Gnome Settings application. Naturally, this works with not just System76 hardware, but anything supported by Fwupd (which is a lot of hardware). Pop also has a bunch of tweaks for common gripes like





We had trouble deciding which of Solus's wonderful backgrounds to capture alongside the Raven sidebar, but cat pictures win every time.

erstwhile Software Centre (now the Snap Store). Flatpaks are supported out of the box too via a custom tool, Sideload. Unlike Apple's walled-garden approach, elementary makes it possible for adventurous users to stray from the curated base camp and brave the open source jungle.

Supporting your distro

"Elementary OS is not free (as in beer). It uses a pay-what-you-want model and when you download the ISO you're asked to make a contribution."

Besides looking pretty and being a pleasure to use, elementary OS is conscious about privacy. Onboarding, which debuted in the 5.1 release, offers to turn on location services or automatically delete temporary files (and optionally Trashed items). This launches on first run for each user (the new user selection screen is also lovely, by the way) and also guides users to the documentation, Night Light settings and AppCenter. Many users will have long-abandoned email clients, opting instead for the web-based offerings from their provider. But elementary's Mail program might just spur those users to make their inboxes local again.

We're looking forward to elementary OS 6.0, which will be based on Ubuntu 20.04, but the team snuck out a point release, 5.1.5, in June which brought yet more nice touches. Being asked for a password occasionally might not seem particularly onerous, but when you encounter the password prompt on a daily basis it gets tiring. Elementary aims to tackle this "authentication fatigue" through contextual authentication, or only asking for a password where it makes sense to do so. If your laptop (which typically only one person uses) asks for a password when you log in, then it shouldn't really need to ask you again when you apply updates, or even install new software. Likewise, you shouldn't be prompted for a password, for example if you just look at (but don't touch) firewall settings. You can follow all the contextual authentication work on Github at **https://github.com/orgs/elementary/projects/74**.

Parental relations

Desktop distros these days tend to all have a parent distribution. That might be something still going (Ubuntu, Debian) or something now defunct (such as Mandrake, where OpenMandriva and Mageia's roots lie). Such distros may be forks (have evolved their own codebase), or they may retain compatibility with their parents. Ubuntu is technically a fork of Debian unstable, whereas Mint is an Ubuntu-derivative. Either way it's rare that something totally freestanding comes out. Which is why we must give credit to the Solus project.

Solus started life as Ikey Doherty's Evolve OS back in 2013. The project's package manager, eopkg, was a fork of PiSi from Turkish distro Pardus Linux. At the time (Evolve remained in alpha until 2015), most interest was centred around its unique Budgie desktop, which used Gnome 3's underpinnings to create a stylish yet traditional experience. Due to a trademark conflict (with the then-UK secretary of state no less) Evolve was renamed Solus, and Solus 1.0 was released at the end of 2015. By then Budgie had acquired its characteristic Raven sidebar (nevermore dig deep to tweak audio or see appointments with Lenore) as well as a substantial following.

By 2017 Doherty announced that he would be working full-time on the project, and Solus had moved to a rolling release model. The team had developed their own tool, ferryd, for rapidly deploying changes to their repositories. While not a strictly Solus project, work continued on his Linux Steam Integration tool (which forced Steam to use distro libraries rather than the antiquities found in its own runtime). Solus's driver management tool saw its first release and Ubuntu Budgie (the desktop has long been available outside of Solus) became an official Ubuntu flavour. Ikey left the project in 2018, leaving it the capable hands of his co contributors, and the rest as they say, is history. Budgie uses the semi-classical Brisk menu, designed in conjunction with Ubuntu MATE, and (like elementary's Pantheon) all development is done in Vala.

The current Solus release, 4.1, comes in four editions (Budgie, Gnome, MATE and Plasma) and packs a range of multimedia features. For gamers, tweaks to the default file limits have been raised so that ESync can be used for better performance in Wine (or Proton, via Steam).

Taking software solace

Since Solus maintains its own repos, you won't find as many packages as in, say, Ubuntu's traditional `.deb` repositories. However, Snap is installed out of the box, so you can now avail yourself of the many offerings in the Snapcraft store. Flatpak and the Flathub remote are only two lines away too:

```
$ sudo eopkg install flatpak xdg-desktop-portal-gtk
$ flatpak remote-add --if-not-exists flathub
```

Eventually these will be integrated in a new plugin-based Software Centre, and eopkg will be replaced by a next-generation package manager dubbed Sol. We look forward to the next Solus release, and indeed Budgie 11.

Next-gen distro tech

Shiny and easy-to-use distributions are one thing, but which distros ship the latest Linux tech? Keep reading to find out...

Fedora is Red Hat's community distro, where new technologies are honed before they make it into their business, meaning Red Hat Enterprise Linux (RHEL). Fedora was the first distribution to see systemd, Pulseaudio and SELinux (the NSA-contributed access control mechanism). Those titles might send shivers down the spines of some readers, but like them or not they're here to stay. It's historically been the best way to experience unadulterated Gnome 3 (stop shuddering you lot). That desktop offers the best Wayland experience, and Fedora was the first to offer Wayland by default (still with the shuddering?). So it's nothing if not a trailblazer distro.

The latest Fedora 32 even enables Firefox's new Wayland backend. Indeed VA-API acceleration, which appeared in Chromium, debuted in Fedora's build over a year ago. So if Fedora receives new features, smoother browsers, why on earth aren't you using it?

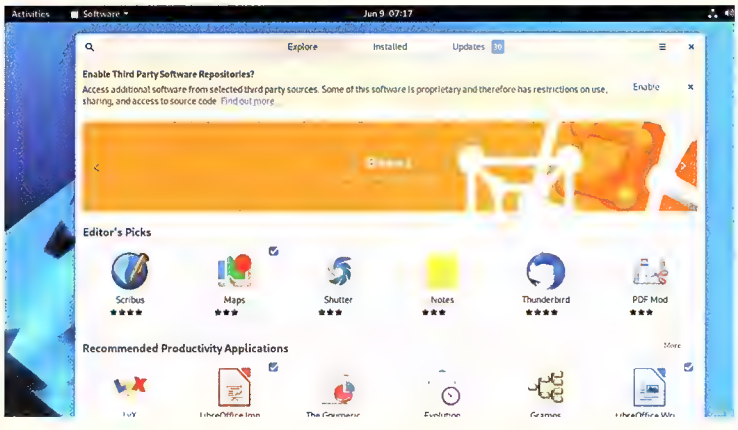
Occasionally Fedora is sidestepped because of its philosophy on software freedom. If you want proprietary software (including the Nvidia driver), or patent-encumbered multimedia codecs, these have to be added through a third-party repo such as RPMFusion or Negativo 17. The codecs issue is much less of a big deal nowadays. Popular streaming sites all use open formats (or at least, in the case of h.264, ones where an open source codec is available) and MP3 became a patent free format in 2017. A free AAC codec was made available shortly afterward, so you can play all your ripped CDs from yesteryear out of the box. Or you could rip them again in a lossless, free format such as FLAC.

Make it easy on yourself

Setting up a traditional third-party Fedora repo requires a certain amount of effort. More so than setting up a PPA for Ubuntu, which is perhaps why it used to be a bit harder to find certain niche software for Fedora. Bear in mind that PPA overload was definitely responsible for the demise of many an Ubuntu install, and third-party builds should always be treated with caution. Nowadays, a new technology Copr, takes all the hassle out of building unofficial Fedora packages. Fedora even offers a Copr build service that will provide you with your own Dnf/Yum repository. Just upload a source RPM file, select your build targets, and you're done. Read more at **https://developer.fedoraproject.org/deployment/copr/about.html**. And, of course, more and more developers are turning to Flatpaks and Snaps (although the latter is disabled in Fedora's build of Gnome Software). So Fedora's comparatively small, but carefully curated repos are no reason to shun it.

Linux hits the mainstream

"With laptop offerings from both Dell and Lenovo, we can direct users who want a rock-solid Linux offering out of the box there with confidence."

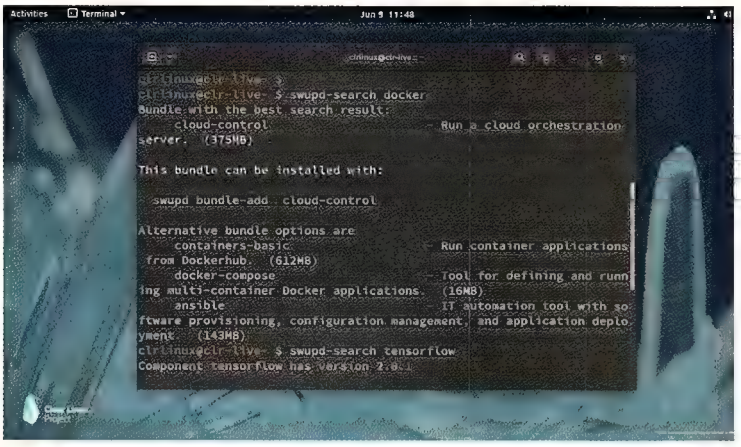


Third-party repos are only a click away in Fedora.

Fedora made the news recently with the announcement that Lenovo will be shipping laptops powered by Fedora Workstation. Writing on his blog Christian Schaller, senior manager for desktop at Red Hat, says "Our engineering team here at Red Hat has also been hard at work ensuring we can support these models very well, be that by bugfixes to kernel drivers or by polishing up things like the Linux fingerprint support". We often have queries about Linux on laptops from readers, and without a particular model to hand it's difficult to give solid advice on compatibility. Now, with laptop offerings from both Dell and Lenovo, we can direct users who want a rock-solid Linux offering out of the box there with confidence.

Christian has been adamant about "draining the swamp" over the course of his past six years at Red Hat. He's not talking about rogue politicians, either. Rather he's addressing desktop issues that for too long have been hastily patched over, where ground-up rewrites were required. He original credits the phrase in this context to a talk by Jim Gettys, whose thoughts you can read at **https://mail.gnome.org/archives/foundation-list/2002-May/msg00005.html**. The latest Fedora includes Gnome 3.36 (the same as Ubuntu 20.04) and we're impressed with the distinct lack of swamps. You may have run into PulseAudio issues in the past, or you may not see any reason to use Wayland over X11, but these technologies were invented to solve problems. And solve them they do. You might also be interested that PipeWire, Wim Tayman's offering to unify media handling, is included by default in Fedora. PipeWire can now do pretty much everything Jack (the rather complicated interface for pro-audio set ups) can, and the next step is to have it take on the duties of PulseAudio too.

If you've ever run Linux on a machine with not enough memory,


Activities
Terminal
Jun 9 11:48
clrlinux@clr-live:~
clrlinux@clr-live ~ $ swupd-search docker
Bundle with the best search result:
cloud-control - Run a cloud orchestration server. (375MB)
This bundle can be installed with:
swupd bundle-add cloud-control
Alternative bundle options are:
containers-basic - Run container applications from Dockerhub. (612MB)
docker-compose - Tool for defining and running multi-container Docker applications. (16MB)
ansible - IT automation tool with software provisioning, configuration management, and application deployment (143MB)
clrlinux@clr-live ~ $ swupd-search tensorflow
Component tensorflow has version 2.0.1

Clear Linux's swupd tool will get you bundles and have you controlling clouds in no time. There are some pleasing background on offer, too.

you'll know that things can get very unpleasant very quickly. Apart from the slowness of using spinning-rust based swap space (which is not an option on some systems), you might find yourself at the hands of the OOM (out of memory) killer. Applications will be slain more or less arbitrarily. Even worse though, is when OOM can't react quickly enough and your desktop grinds to a halt. You can't move the mouse pointer, you can't switch to a virtual terminal, you probably can't even SSH in to kill things manually.

We've run into this memory-pressure situation a few times when running one too many virtual machines. Like when you're writing a big feature about lots of distros and then it makes it late. Anyhoo… Fedora 32 includes the EarlyOOM daemon, which should step in before it's too late.

Fedora goes much further than the desktop. Naturally it has a server offering, and we've already mentioned its Flatpak- and container-focused Silverblue desktop effort. But since Red Hat purchased CoreOS in 2018, it's now in charge of the distro formerly known as CoreOS Container Linux, now dubbed Fedora CoreOS. This will very likely be the future for managing container-based workflows securely, and in particular massive server deployments. And from the very big to the very small, in the form of Fedora IoT, its offering for the tiny things that will be running our cities and lives in the coming years.

A Clear winner

One distro we haven't covered much, but perhaps should, is Intel's Clear Linux. This is aimed at professionals using Intel hardware to do advanced things with container and cloud technologies. In its own words it's "not intended to be a general-purpose Linux distribution". Be that as it may, it consistently scores favourably in Phoronix's tireless benchmark comparisons and a desktop edition is available so you may want to have a gander. Clear Linux abstracts application packages into the concept of Bundles, which enable a bunch of related programs to be installed at once. Since Clear Linux has its own repository you might not find your favourite applications, but this is exactly part of the problem Flatpaks aim to solve, and installing the Flatpak bundle is easy.

Clear Linux bundles use compiler optimisations, enabling AVX512 vector instructions on suitable endowed hardware. So, for example, if you're running TensorFlow, you'll benefit from kernel tuning, AVX routines in Glibc, AVX optimisations in Python, tweaked Numpy/Pandas modules and finally optimisation at the very top of the stack in Tensorflow's Eigen component. Clear Linux uses a stateless design concept so the whole OS can be effectively factory reset by clearing /etc and /var. This doesn't work on other distributions so please don't try it. But do try all of the distros we've mentioned here, and feel free to shout at/email us for not mentioning your favourite next-generation offering.

What about Arch?

Arch users may be shocked to find their distro of choice not mentioned in this page of new technology, and perhaps they have a point. But then so too might Gentoo or Linux from Scratch users, who also have access to the latest versions of everything, and can also compile it with whatever optimisations suit their CPU. We've focused instead on what distros offer out of the box, and with Arch, and more so with Gentoo, well, you barely get a box. Be that as it may, Jason uses Arch, and so should you.

Manjaro did the unthinkable and made Arch Linux easy to use, and continues to be one of the most popular desktop distros around. Manjaro doesn't directly use the same repositories as its progenitor, some things move quickly on Arch, and Manjaro has a release cadence to follow to aid a desire not to break its own packages. So you won't find quite the same bleeding-edge versions as you would in Arch, but the selection will be far from stale. And bugs that may have found their way into the stable Arch repos will have been ironed out by the time they reach Manjaro. We like that Manjaro is getting the Xfce desktop some attention – lightweight doesn't have to mean light on features. And if you want a beautiful take on KDE's Plasma desktop you can also get that through Manjaro's Plasma edition.

HOW TO MAKE YOUR

Smart assistant *smarter*

Fix issues and get more from any smart assistant.

Every smart assistant, like every computer platform, is different in its own way. A Mac is not the same as a Windows PC or Linux box; although they share a vast amount in terms of concept and design, while they might use some of the same components or even (technically) some of the same underlying code, they are distinct.

They're powered by very different engines, they have different levels of knowledge available to them, they have different hardware makeup and methods of connectivity. But one thing does tie Siri, Alexa, Google Assistant and minor assistants like Bixby and Cortana together: they can all be as dumb as a box of frogs when they feel like it.

Say what?

Whichever platform you've staked your claim on, there are things you can do to improve both your AI assistant's ability to listen and its ability to deal with what it thinks it has heard.

If you use discrete hardware to talk to them – an Amazon Echo, Apple HomePod or Nest Home device, for example – you should be careful about where that device is positioned in the room. These tend to use an array of far-field microphones to listen for their wake word, but if they're not catching the sound correctly they may well miss (or at least mishear) what you have been trying to say.

Begin by shifting the unit away from the wall slightly, so that they're not catching too many echoes from nearby walls; this can also fix any network connectivity issues you might be having. Make sure there's no noise in the vicinity that could drown out the sound heard by those microphones; fans, open windows, air conditioners and the like can block an assistant's ears significantly.

If you're using an Amazon Echo device, there's a handy test you can do to see if any of the microphones might be blocked or obscured somehow – just call out the wake word from different locations in your room. The blue ring will light up, with one of its segments a brighter blue to indicate the direction it thinks the sound came from. A broken or blocked mic (and sometimes wall echoes) will cause issues with triangulation, and the indicator will point in the wrong direction. Try a little compressed air to clean out any blockages, and make sure there's nothing obscuring the top of the device.

Third-party assistants support systems like Amazon's Alexa and Google Assistant without necessarily using the same hardware, and thus may have even less acute hearing; be extra careful where these are placed. It goes without saying that, even with a microphone array listening all around, smart assistants can be baffled or misactivated by TVs and speakers. There's some delicious irony in there, but we'll just say that you're better off leaving the volume at a lower level (or moving the hardware away from the source of noise) if you're likely to be talking to your smart speaker a lot.

On a phone or PC/Mac, you don't quite have the same positional luxury. Phones usually aren't so difficult to deal with, because you can (and naturally will) pick them up and put them near your mouth; the lack of a far-field array is probably a benefit here, because it cuts down on most accidental actuations. In terms of Siri or Cortana on a compatible Mac or PC, voice actuation offers a little conundrum; do you fight to make sure you can always be heard, or ignore it altogether? Siri and Cortana can be brought up in a couple of clicks, or a tap of the MacBook Touch Bar. Adding an external mic like that from your headphones can help – make sure it's selected in Sound Preferences – but is it really worth worrying about given that you'll likely be physically next to your PC or Mac at any time you'd want to use it?

There are things you can do to improve your AI assistant's ability to listen to commands.

Testing, testing

Assistant stupidity is not always entirely the fault of microphones. The things you say to an AI are not processed locally by the device, generally – they're sent off, worked on by some faceless computer in the cloud, and the results are sent back. This can be a problem. While AI agents have a

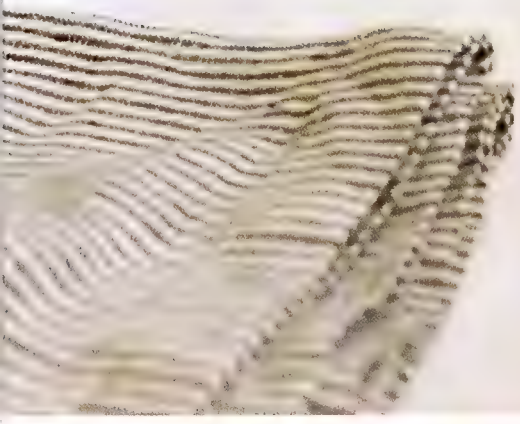
Which is smartest?

Not all smart assistants are created equal

We've looked at Loupe Ventures' research, and the company's most recent suite of AI IQ tests has determined that the Google Assistant is the smartest thing going. That's both in its digital assistant form (as in, when accessed through a phone) and when powering a smart speaker. It understands best, and it provides relevant responses most frequently. That said, each time Loupe Ventures does a new test, every major platform improves a little; Alexa took the 'most improved' crown in the most recent suite.

Too bad for Siri? Not so fast – it seems that Apple's assistant is, by their metrics, by far the smartest in the 'command' category, which relates to its ability to perform on-phone functions like texting, calling and emailing. We're not surprised, as that's very much Siri's wheelhouse: there's a subtle divide between it and the other pair that makes each side of it independently good. It's probably not worth the hassle of running Google Assistant or Alexa on an iPhone when Siri can do the job so much better; similarly, if you don't want to invest in a HomePod, it's cheaper and makes more sense to opt for one of the others around your home.

If you're smart, your smart speaker can offer up tunes, facts and all the rest when you're in the garden.



Want the 'cleverest' home assistant around? Go for Google.

Multiroom artificial intelligence speakers ›

Sonos One

$480 | sonos.com

It should come as no surprise that the room-filling Sonos One is an exciting compact smart speaker. You can't help but notice it; there are cheaper options, but the additional multiroom expertise inside may be worth the extra expense.

Bose Portable Home Speaker

$449 | bose.com.au

Bose's all-in-one device has a handle, so you can cart the smarts around with you – as long as you're within Wi-Fi range. It's loud, water resistant, has a big battery, and it too is multiroom ready.

Sonos Move

$615 | sonos.com

Sonos has its own 'portable', the Move, though it's more of a luggable, at over twice the weight of Bose's smaller smartie. There's a weight to its sound as well as its form, and dual-assistant support means it's useful even if you leave it in one spot.

You can probably skip voice training if you'd rather your assistant didn't get all HAL 9000 and start calling you by name.

vast (and ever-growing) supply of data to compare captured snippets of speech against, doing so quickly demands a more refined approach: they'll choose a specific section of the available data.

Broadly, this is regional. In Australia your assistant will use the Australian dataset; if you're in India, you're likely to have a vastly different accent, so the assistant will work with a localised dataset – except when it doesn't. Make sure your localisation settings are correct if you want to be properly understood; while it might be fun to have Google Assistant chat to you in an American accent, it might also make interpreting your own voice more difficult. On the flip side, both Alexa and Google Assistant now support multilingual mode. Alexa can understand (and talk back) in English and French if your region is set to Canada, for example. Google gives you a choice of any two of its supported languages.

You can also, on most assistants, perform some level of voice training. This doesn't take long, but it further narrows the dataset that assistant looks at when working out what you've said, and allows the assistant to tell you apart from other people that might use it. That's great, except when it isn't: there's some small anonymity when talking to an untrained assistant, barring the fact that whatever you say is linked to the logged-in account. You can probably skip voice training if you'd rather your assistant didn't get all HAL 9000 and start calling you by name.

Speaking of names, you can change Alexa's wake word if you're getting a few too many accidental actuations; there's the delightfully Star Trek-esque 'Computer', as well as 'Amazon' or 'Echo' on offer either by asking the assistant verbally or by changing a setting in the app. Amazon seems to be the only company to have built this function into the limited circuit used to listen for a wake word, so if you're using Siri or Google you'll be stuck with the standard names.

Each assistant has its own level of extendability. Siri, for example,

Smarts without the speaker

You absolutely don't need a smart speaker. Don't rush to forget everything you've just read, though: smart speakers and smart assistants are two separate entities, and if you want to try out the brains of any of the big smart AIs you can do so with nothing but your phone.

Install the Alexa or Google Assistant apps on a modern phone, and you're ready to go. There's even a Cortana app which, while it is definitely the fourth-string AI, is super-useful if you're using Microsoft tools.

Once installed, you can use Siri's shortcut feature (found in Settings > Siri & Search) to activate these with only your voice. When it's set up (and you'll be given an option in-app, in most cases) an admittedly awkward phrase like "Hey Siri, OK Google" will fire one up, and you can talk to it as if it were the default AI.

Not all smart speakers are created equal – you can't necessarily move a sound bar but there are other ways to improve its abilities.

has its particular set of commands and abilities, but not a huge amount of third-party extras – while the likes of Alexa can be added to pretty easily.

That only paints part of the picture, though. Yes, you can add smarts to Alexa through its vast array of so-called skills, but they are of varying usefulness. Sometimes they're required, like when you add a new piece of hardware to your home. Sometimes they're just fun little excursions. But very rarely are they useful. It's possible you'll find something for your niche interests, but the quality of third-party additions varies.

Siri's close integration with the Apple ecosystem actually makes it a little smarter with a little less effort. Add devices to your HomeKit network and it'll know about them. With only a little fiddling, you can teach it the relationship of you and your contacts.

Many consider it to be a little more inflexible than its rivals, but that really depends on how you're going to use it. With their cheap devices, Google and Amazon make it much easier to fill your home with smart assistance, but again, Siri's know-it-all attitude to Apple devices (and deep integration) makes it a much smarter cookie if you're all-in on Apple.

Smart follow-ups

Want to really make your smart assistant smart? Smarten yourself up. Recent developments means all three major players have a whole lot more synapses firing, with quality of life improvements many people don't even know are there.

Both Google Assistant and Alexa now support some kind of follow-up mode. With Alexa you'll need to switch this on in the app; for Google devices, it should be enabled by default. It means you can combine commands – "Hey Google, play Van Halen and set the volume to 10" – or take advantage of a brief few-second listening period after you've asked a question. If you ask how the weather is and get a typically negative answer, you can set a reminder to bring an umbrella without needing to use the wake word again.

Even if you don't use something like follow-up mode, learning how best to talk to an AI assistant makes the whole process feel more slick.

Contrast the laborious process you'll have to go through after you say "Alexa, set a reminder" (and it is a long-winded one, at best) with simply saying "Alexa, remind me to go for a walk at 6pm tomorrow". ■

Smarter wheels ›

Garmin Drivesmart 65

$328 | garmin.com

The Drivesmart 65 builds Alexa support right into it. You can ask for directions, or use any Alexa feature you like. You get hands-free calling, full Australian and NZ map regions, and it's a good size.

Roav VIVA Pro

$175 | goroav.com

This two-port 12V charger gives access to Google Assistant even when your phone is locked; connect it via Bluetooth or an aux cable to your car stereo, and it'll pipe your tunes right in. Neat, tidy, and pretty cheap.

Nextbase 522GW

$399 | nextbase.com

One of the best dash cams you can buy, with great resolution, a strong suite of safety features, automatic emergency calling and, yes, Alexa built in. The camera features are great, and Alexa is a bonus.

$79 | www.amazon.com.au/echoauto

Amazon Echo Auto

A microphone that connects to your phone and to your car. But, do you need it?

Now that you've read about how to improve Alexa and her digital companions in your home, it's time to find out how to get it working in your car. To that end, Amazon has recently released the Echo Auto which is a simple device, featuring two buttons, a light-strip and eight (count'em) microphones. It promises to hear whatever you're saying, even in the noisiest vehicle. At only $79 it's not going to break the bank but, is it worth buying?

The Echo Auto a slight device that weighs only 45g. It connects magnetically to an air-vent mount which is simple to attach. The downside is that it requires USB power from the cigarette lighter and this requires an unsightly cable to be plugged, awkwardly, into its side. Once installed, you can connect it to your car's stereo via Bluetooth or the included 3.5mm Aux audio cable. Either way, you'll need to set it up via the Alexa app on your phone first.

If you're finding that puzzling, you're not alone. In Australia, we're well versed in having our phones mounted in front of us on the windscreen. Consequently, the notion of connecting your phone to a separate microphone which then connects to your stereo introduces a middleman whose function isn't immediately obvious: most phones already connect directly to the car, in the same way that the Echo Auto does. Nonetheless, if you've an older car without Bluetooth or you find that your vehicle is too noisy – whether it's due to noise from road wind or kids – the eight microphones might sound attractive.

If you don't want Alexa listening to you, you can press a button to stop it. If you don't feel like raising your voice, the second button will activate Alexa and allow you to talk without the rigmarole of vocally addressing it first. That you can already do all this with the Alexa app on your phone is something we'll ignore for the rest of this review.

Once up and running you can ask Alexa to potentially do a multitude of things but, for many drivers, this will mean, "Play Music." Just note that everything streamed will come via your phone's data plan. Amazon promotes its ability to provide directions but, if you ask for them, the default maps app will open on your phone – and then, only if it's unlocked. This feels like a critical feature that's missing. At least the device can tell you what the traffic is like on the way somewhere.

As we've seen elsewhere in this feature, you'll get more out of Alexa the more you put in. However, when compared to a fully functioning Google Assistant that's tied directly into Google Maps, we find ourselves wondering, 'What's the point?" If Alexa runs your life and you're not happy with how your phone already accesses it in your car, then the Echo Auto might be attractive. However, it requires a smartphone to operate, it's not compatible with all smartphones (or cars) and if you own a smartphone, you probably won't need it.

NICK ROSS

BlueTooth, 3.5mm audio jack, 8x microphones; 3.5mm audio jack, twin USB port power adapter, 47mm x 85mm x 13mm, 45g.

If Alexa runs your life and you're not happy with how your phone already accesses it in your car, then the Echo Auto might be attractive.

It needs a smartphone to function but if you already have a smartphone the Echo Auto is superfluous.

★★☆☆☆

PC BUILDER

WHAT'S HAPPENING IN THE AUSTRALIAN PC MARKET

System News

This month, Mark Williams wonders where all the Ryzen 4000 laptops are.

Dell's G15 SE is one of the first Ryzen 4000-series laptops to come from one of the major manufacturers.

As the COVID-19 pandemic continues, the economy seems to be bifurcating into boom or bust businesses. You are either doing really well at the moment, or you're struggling.

Fortunately, I'm seeing the boom side of the economy at my work, and like so many others as a result, our IT needs have ballooned with a great need to order everything from printers to monitors, new PCs and more. One thing that caught my attention during all this was when we needed some more laptops. I was looking at what Dell had on offer and wondered where are all the Ryzen 4000 series laptops? There were none! Dell had the latest 10th Gen Intel products, but the only AMD parts on offer were old Ryzen 2000 series units.

This was confusing, as AMD has some very compelling APUs currently that frequently beat out Intel's parts not only in performance, but also battery life and thermals. Ryzen 4000 parts should be on sale by now as they've been out for five months since their launch in March.

What's the story? It turns out that AMD is something of a victim of its own success. Not long ago a laptop brand called XMG based in Germany notified customers that laptop orders with Ryzen 4000 APUs were being delayed by four to six weeks, as its supplier couldn't source enough APUs from AMD to make the laptops. Contacting AMD directly, XMG was told that "this is an industry-wide shortage and there is no way around it". Apparently big OEMs have finally caught on that AMD is making some very compelling mobile parts now, and have flooded the company with orders, causing the shortage.

Whether TSMC can ramp more 7nm fabrication capacity to help the situation, or if AMD can sacrifice the production of another part to free up some of its allocated capacity at TSMC, remains to be seen. It could also be the reason why the desktop 4000 series APUs haven't launched yet. AMD simply can't get them made.

As bad a situation as it is for buyers and OEMs, it's the best of problems to have if you're AMD. It is experiencing the highest levels of CPU market share since the Athlon64 days. Mercury Research recently published some market share numbers, and by its reckoning AMD's mobile processor shipments made up about 20% of the market last quarter. In a market segment that Intel has heavily dominated for so long, that is an amazing feat! AMD has essentially doubled its market share in the space of two years and, with all this pent-up demand, it seems that will only continue to rise.

There's already good news around the corner for those wanting Ryzen 4000-powered laptops, especially of the gaming sort. At the time of writing Dell is finally offering a Ryzen 4000-powered laptop in the form of the G5 15 SE, and our friends over at Aftershock PC said "[We] are about to launch our first AMD [laptop] in the next week or two, stock is finally coming in! Even though it will be quite limited. We have been trying to get them for many months [as] there have been continuous supply issues in getting allocation to Australia". So keep an eye out for that and if you're wanting an AMD powered laptop, it's just a matter of time

"One thing that caught my attention during all this was when we needed some more laptops. I was looking at what Dell had on offer and wondered where are all the Ryzen 4000 series laptops? There were none!"

MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

Shop Talk

In your view has AMD made any headway on increasing its market share in the laptop segment? What's holding it back?

JAIMIE, LEADER COMPUTERS:
"We have seen a marked increase in AMD offerings across our tier one brands including Lenovo, Asus and to a lesser extent HP. It's an impressive turnaround for AMD compared to two years ago; they have definitely earned consumer confidence. The performance versus cost ratio is still strongly in their favour, especially when you take into account the integrated Vega graphics available in some models, which hands the Intel HD offering its own entrails!"

RICHARD, AFTERSHOCK PC:
"At the current point in time, I believe AMD could and should be making huge inroads into the laptop market. The main thing holding them back at the moment seems to be supply. Stock continues to be delayed and in very short supply in Australia (from what we are seeing anyway). As such, it is really just going to be a matter of time to see how they are adopted by consumers, but my feeling is that they are going to be very big based on the number of requests we get for them." ■

Market snapshot

A sampling of PC systems available this month.

$1,999 | tinyurl.com/APC485PCC

PC Case Gear Fusion 1660 Super

This system feels safe. There is everything you should expect at this price point, but nothing that stands out to make it particularly interesting. In fact, relative to the Aftershock system, the specifications in this system look decidedly dull. A solid CPU paired with a mature motherboard will see you into the Ryzen 4000 series should you want to upgrade later. The 3200MHz RAM – while ok – is a letdown when it is known that Ryzen 3000 best benefits from 3600MHz+ sticks. The 256GB SSD is again, ok, but for a gamer might feel small after a few large game installs. The power supply is similarly satisfactory for this configuration.

CPU: AMD Ryzen 5 3600, **COOLER:** OEM, **MOTHERBOARD:** Asus Prime B450M-K, **GRAPHICS:** Asus GeForce GTX 1660 Super TUF Gaming X3 OC 6GB, **MEMORY:** Corsair Vengeance RGB Pro 16GB 3200MHz DDR4, **STORAGE:** Adata XPG SX8100 M.2 NVMe SSD 256GB, Seagate Barracuda 2TB HDD, **POWER SUPPLY:** Super Flower Leadex III Gold 550W, **CASE:** Phanteks Eclipse P360X RGB

$1,947 | tinyurl.com/APC485AFT

Aftershock PC The Bolt

The recommended specification of this system is quite the sweet spot deal. Targeted at 1080p gaming, the GTX 1660 Super will give you a great experience often with most game details turn up high. The CPU is best in class still and won't be a bottleneck any time soon, productivity or otherwise. The most interesting part of this system is the B550 motherboard. With no PCIe Gen 4.0 SSD in use, it makes this expensive parts inclusion for seemingly no extra cost quite the feat. It'll allow upgrading to Ryzen 4000/5000 when they become a real possibility as too PCIe Gen 4.0 SSDs or graphics cards. A well-ventilated case, fast RAM and nice-sized SSD and PSU make for a perfect build to expand upon down the track.

CPU: AMD Ryzen 5 3600, **COOLER:** OEM, **MOTHERBOARD:** Gigabyte B550 Gaming X, **GRAPHICS:** Zotac GTX 1660 Super 6GB, **MEMORY:** 16GB DDR4 3600 MHz, **STORAGE:** 512GB M.2 NVME SSD, 1TB HDD, **POWER SUPPLY:** FSP/EVGA 600W, **CASE:** Fractal Design Meshify C

$1,204 | tinyurl.com/APC485PLE

PLE Home Everyday

A solid choice for any home office setup, and at a decent price too, so one starts to imagine what the catch is. And if you look deeper, this starts to look like a poor choice if you like well-balanced systems. The CPU is definitely the star, with six well clocked cores with hyperthreading, but matched with just a single stick of memory it will see some performance loses in memory intensive tasks. Then there is the hard drive as the only mass storage, which will make starting up and loading programs a go-make-a-coffee affair. There are just four USB ports on the rear IO panel, and the oddly over specced power supply. As it is, we would not recommend this system.

CPU: Intel Core i5 10400, **COOLER:** OEM, **MOTHERBOARD:** Asus Prime H410M-A, **GRAPHICS:** Integrated, **MEMORY:** GeIL 8GB Single DDR4 Pristine C19 2666MHz, **STORAGE:** Seagate Barracuda 1TB HDD, **POWER SUPPLY:** eVGA GD Series 600W, **CASE:** Corsair Carbide 100R

$999 | tinyurl.com/APC485COM

Centre Com HOME R5

One of the more unique builds you'll find, largely due to the CPU powering it. The R5 3500X was officially only launched in China. So, finding one in a system in Australia is a rare treat. Able to keep pace with the R5 3600 in light to medium tasks, this system is perfect for any home office, especially in a working from home situation. The two largest let downs of this system is the A320 motherboard and the anaemic 350W PSU. While satisfactory for this build don't expect to get away with any major upgrades without replacing them. Good storage capacities and with dual channel memory enabled, for the price, it's a unique way of satisfying its intended target market.

CPU: AMD Ryzen R5 3500X, **COOLER:** OEM, **MOTHERBOARD:** A320M based, **GRAPHICS:** AMD R5 230, **MEMORY:** 16GB DDR4 Team Elite, **STORAGE:** 480GB SSD, 2TB HDD, **POWER SUPPLY:** 350W 80+ bronze rated, **CASE:** Unknown brand

BLUEPRINTS

VALUE- AND PERFORMANCE-DRIVEN HYPOTHETICAL BUILDS

PC BUILDER

Budget

Bangs for few bucks.

Both budget builds have seen small increases this month, with the AMD system just managing to remain the cheaper option. We've made plenty of changes here; first, both motherboards are now Phantom Gaming 4 models from Asrock. The Intel build has received the Z390 motherboard because it's the most affordable option, but the AMD build has given us a chance to both upgrade and make a saving with a new B550 board, bringing us forward a generation.

This should see minor general improvements in performance and power management, but the crucial addition is PCIe 4.0 support, allowing us to use 4th-gen M.2 SSDs for maximum transfer speeds. We're not doing that yet, though. Why? Because this is a budget build, and currently the smallest PCIe 4.0 drives available are all 500GB models costing upwards of $250. Still, there's a good range of cheap, low-capacity SATA III SSDs available now, so we've swapped the boot drives in both builds for 120GB Teamgroup GX1 SSDs. If cheaper PCIe 4.0 SSDs become available soon, we'll take advantage of them.

The GPUs didn't need changing, and we're sticking with the EVGA GTX 1660 Super Black Gaming for now. The 5600 XT is still slightly expensive for our liking, but it does perform well. We've also coalesced back down to a single PSU for both builds, with the ever-reliable EVGA 450 BR. While similar power supplies are sometimes cheaper during sales, the EVGA 450 BR remains an excellent deal.

The last change we've made is the memory in the AMD system, with a switch to a different 2x16GB kit to shave a few dollars off the price while keeping the same frequency and CAS latency. Performance isn't improved hugely in either system this month, but we've gained some small boosts here and there.

"The AMD build has given us a chance to both upgrade and make a saving with a new B550 board, bringing us forward a generation."

AMD INGREDIENTS

PART		PRICE
CASE	BITFENIX NOVA TG	$120
PSU	450W EVGA 450 BR **NEW**	$69
M/BOARD	ASROCK B550 PHANTOM GAMING 4 **NEW**	$219
CPU	AMD RYZEN 5 3600	$299
GPU	ASROCK CHALLENGER D RX 5600 XT 6GB	$469
RAM	16GB (2 X 8GB) TEAM T-FORCE VULCAN Z @ 3,000MHZ	$109
SSD	120GB TEAMGROUP GX1 2.5" SATA III **NEW**	$38
HDD	1TB SEAGATE BARRACUDA HDD	$70
OS	UBUNTU DESKTOP LINUX 18.04 LTS 64-BIT	$0
PRICE:		**$1,398**

INTEL INGREDIENTS

PART		PRICE
CASE	BITFENIX NOVA TG	$120
PSU	450W EVGA 450 BR **NEW**	$69
M/BOARD	ASROCK Z390 PHANTOM GAMING 4 **NEW**	$239
CPU	INTEL CORE I5-9600K	$369
GPU	EVGA GEFORCE GTX 1660 SUPER BLACK GAMING 6GB	$379
RAM	16GB (2 X 8GB) G.SKILL RIPJAWS V SERIES @ 2,400MHZ	$129
SSD	120GB TEAMGROUP GX1 2.5" SATA III **NEW**	$38
HDD	1TB SEAGATE BARRACUDA HDD	$70
OS	UBUNTU DESKTOP LINUX 18.04 LTS 64-BIT	$0
PRICE:		**$1,413**

"The Intel Core i7-9700 is actually now cheaper than the i7-9700F. It's a strange turn of events, since the chips are near-identical."

PC BUILDER

Mid-range

Punching above its weight.

Again, we have small savings on both mid-range systems this month. An excellent deal on the Corsair Vengeance LPX DDR4-3200 has given the memory in the AMD build a minor speed bump (of 200MHz, with no change in CAS latency) and knocking a few bucks off the price too.

Meanwhile, the Intel system has adopted the same memory as its budget counterpart: Performance is basically unchanged, but we've saved a few dollars. Since memory speed has little to no impact on Intel CPU performance, there's no need to splash out – capacity and latency are all that matter.

A price hike on the Corsair CX650 made us opt for new 650W power supplies. Both the AMD and the Intel machine get the MasterWatt 650 from Cooler Master, equipped with a low-noise Silencio fan. Speaking of fans, we saved a bit more cash by swapping to the Noctua NH-U12S CPU cooler for our AMD build. This is a slight downgrade – the NH-U12S only has one fan as opposed to the previous Corsair A500's two – but Noctua's coolers are always a good choice.

The Ryzen 7 3700X isn't going anywhere, but the Intel Core i7-9700 is actually now cheaper than the i7-9700F. It's a strange turn of events, since the chips are near-identical, save for the 9700F's lack of integrated graphics. The i7-9700 is joined by a new motherboard too, the MSI MPG Z390 Gaming Edge AC, saving us $60. The AMD build also scored a new motherboard: The Asus TUF Gaming X570-Plus, which is excellent value at $429.

We shopped around for different Radeon GPUs, but the MSI RX 5700 remains excellent value right now. Our previous RTX 2060 rose by the same amount, so we've shifted over to Gigabyte's factory-overclocked model to keep our price level. Elsewhere, small savings made us stick with the parts we had already. Fractal Design's Meshify C case remains a great choice.

AMD INGREDIENTS

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	$189
PSU	650W COOLER MASTER MASTERWATT **NEW**	$109
M/BOARD	ASUS TUF GAMING X570-PLUS **NEW**	$429
CPU	RYZEN 7 3700X	$525
COOLER	NOCTUA NH-U12S **NEW**	$129
GPU	MSI RADEON RX 5700 8GB	$649
RAM	16GB (2 X 8GB) CORSAIR VENGEANCE LPX @ 3,200MHZ **NEW**	$120
SSD	500GB CORSAIR FORCE MP600	$225
HDD	1TB SEAGATE BARRACUDA HDD	$70
OS	WINDOWS 10 HOME 64-BIT OEM	$140
PRICE:		**$2,585**

INTEL INGREDIENTS

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	$189
PSU	650W COOLER MASTER MASTERWATT **NEW**	$109
M/BOARD	MSI MPG Z390 GAMING EDGE AC **NEW**	$329
CPU	INTEL CORE I7-9700F **NEW**	$549
COOLER	NOCTUA NH-U12S **NEW**	$129
GPU	GIGABYTE GEFORCE RTX 2060 OC 6GB **NEW**	$599
RAM	16GB (2 X 8GB) G.SKILL RIPJAWS V SERIES @ 2,400MHZ **NEW**	$109
SSD	500GB WESTERN DIGITAL WD BLACK SN750 M.2 PCIE SSD	$150
HDD	1TB SEAGATE BARRACUDA HDD	$70
OS	WINDOWS 10 HOME 64-BIT OEM	$140
PRICE:		**$2,373**

PC BUILDER

Turbo

Hail to the chief.

Before we get into the nitty-gritty of this: At the time of writing, *Death Stranding* on PC is free with both of the EVGA 2080 Supers we're using in these two builds (the KO Gaming in the AMD build, and the Black Gaming in the Intel build). Snap that up! Anyway... high-end power supplies seem to be stabilising somewhat in the price department, so we'd recommend grabbing a Corsair RM850x at just $269 before the price rises again. You can see the same PSU in both turbo builds this issue.

In the AMD machine, we've upgraded our motherboard to the excellent MSI MEG X570 Unify. Some dedicated readers among you may remember this as one of the first X570 boards we got our hands on, and it's still a great choice for any 3rd-gen Ryzen build. We've also swapped out our memory, sticking with G. Skill's TridentZ range but now opting for the newer, flashier TridentZ Neo.

As we mentioned earlier, we're using EVGA's RTX 2080 Super KO Gaming in this machine now. Lastly, the 1TB model of the Corsair Force MP600 SSD is no longer the most affordable option for a 1TB PCIe 4.0 drive; Patriot has come in strong with the Viper Gaming VP4100, providing up to 5GB/s transfer speeds.

The Intel system is getting a far more concrete improvement this month: A shiny new CPU, with the Intel Core i9-10900K. This is selling fast, but hopefully will be restocked by the time you read this. With 20 threads across 10 cores clocked up to 5.3GHz, this should show a solid performance boost when combined with the new Asus ROG Strix Z490-E Gaming motherboard. Fortunately, the LGA-1200 socket is compatible with LGA115X coolers meaning we have plenty of choice for coolers. That said we've gone for Fractal Design's Celsius+ S28 Dynamic X2 AIO cooler, which sports an omni-compatible CPU bracket.

"With 20 threads across 10 cores clocked up to 5.3GHz, this should show a solid performance boost."

AMD INGREDIENTS

PART		PRICE
CASE	NZXT H710I	$309
PSU	850W CORSAIR RM850XA **NEW**	$229
MOBO	MSI MEG X570 UNIFY **NEW**	$529
CPU	AMD RYZEN 9 3950X	$1,219
COOLER	CORSAIR ICUE H115I RGB PRO XT 280MM	$219
GPU	EVGA GEFORCE RTX 2080 SUPER KO GAMING 8GB **NEW**	$1,249
RAM	32GB (2 X 16GB) G.SKILL TRIDENTZ NEO @ 3600MHZ **NEW**	$299
SSD	1TB PATRIOT VIPER GAMING VP4100 M.2 PCIE SSD **NEW**	$259
HDD	6TB SEAGATE BARRACUDA	$269
OS	WINDOWS 10 HOMES 64-BIT OEM	$140
PRICE:		$4,721

INTEL INGREDIENTS

PART		PRICE
CASE	NZXT H710I	$309
PSU	850W CORSAIR RM850X **NEW**	$229
MOBO	ASUS ROG STRIX Z490-E GAMING **NEW**	$539
CPU	INTEL CORE I9-10900K **NEW**	$999
COOLER	FRACTAL DESIGN CELSIUS+ S28 DYNAMIC X2 PWM BLACK 280MM **NEW**	$249
GPU	EVGA GEFORCE RTX 2080 SUPER BLACK GAMING 8GB	$1,349
RAM	32GB (2 X 16GB) CORSAIR VENGEANCE RGB PRO @ 2,666MHZ	$269
SSD	1TB SEAGATE BARRACUDA 510 M.2 PCIE SSD	$289
HDD	6TB SEAGATE BARRACUDA **NEW**	$269
OS	WINDOWS 10 HOMES 64-BIT OEM	$140
PRICE:		$4,641

PC MASTERCLASS

A PC PROJECT BUILD WITH A PURPOSE

BUILD IT

The flagship Comet Lake PC

We look at what you can achieve with Intel's latest processors in the world of gaming and rendering. Zak Storey

Comet Lake hath cometh, and with it Intel has brought a bevy of new features into the headlines of its latest processors. That means a new socket, a new chipset, more cores (more heat), and of course, more performance.

But is it quite enough to compete with the juggernaut that AMD has become? We already know that 3rd-gen Ryzen represents incredible multi-threaded power at a comfortable price. But the one area those zenified processors don't quite match up is typically in the gaming department. On the whole AMD's IPC (instructions per clock cycle), although much improved on Ryzen's debut, still aren't up to Intel's level.

The big question, then, is whether Intel's IPC advantages in its flagship 10-core processor give it the edge over the AMD Ryzen 9 3900X in both gaming and rendering, and if so, by how much? And is that enough to warrant the extra $110 in price? That's what we're looking to find out.

But before you dive into your email inbox, ready to lambast us for once again featuring a crazy, over-the-top gaming PC, you might want to take a quick glance over last month's *APC*. There you'll find Christian's take on a fantastically quiet audio recording workstation, ideal for any and all after inspiration on how to throw themselves into the world of benignly silent computing.

Yes, we've heard your concerns, and we feel them too. Now that's out of the way, let's see what we included in this wee beastie of ours, and why.

"The big question, then, is whether Intel's IPC advantages in its flagship 10-core processor give it the edge over the AMD Ryzen 9 3900X in both gaming and rendering, and if so, by how much?"

ZAK STOREY
Zak likes to unwind by tidying his cables.

PART		PRICE
CPU	INTEL CORE I9-10900K	$999
GPU	ZOTAC GAMING GE-FORCE RTX 2080 SUPER AMP EXTREME	$1,349
M/BOARD	GIGABYTE Z490 AORUS PRO AX	$499
MEMORY	32GB (4X8GB) CORSAIR DOMINATOR PLATINUM RGB WHITE @ 3600 MHZ	$519
SSD 1	1TB CORSAIR FORCE MP510 M.2 PCIE 3.0 SSD	$240
SSD 2	2TB WD-BLACK SN750 M.2 PCIE 3.0 SSD	$599
COOLING	EKWB EK-AIO 360 D-RGB	$229
PSU	750W CORSAIR HX750I 80+ PLATINUM	$357
CASE	CORSAIR ICUE 465X MID TOWER	$249
TOTAL		$5,040

AORUS
TEAM UP, FIGHT ON
GIGABYTE
Z490
Support 10th Gen Intel Core Processors
Socket 1200
DDR4
USB3.2
Designed in Taipei
RESERVED FOR FUTURE
CORSAIR
FORCE SERIES
MP510

The Hardware

CPU

Intel Core i9-10900K

$999

The crem de la crem of Intel's arsenal, the Intel Core i9-10900K is the kingpin at the top of Team Blue's latest processor pile. Complete with 10 cores, 20 threads, 20MB of smart cache, and a 5.3GHz max turbo speed across two cores, it's Intel's fastest mainstream processor to date.

It's certainly not flawless, however. With those 10 cores comes an incredible amount of both heat and power draw. 14nm++ isn't the best manufacturing process to leverage this design on, and because of that, even at stock with a triple rad/360mm AIO, you're looking at temps well up into the 80 C range. On top of that, power draw can often be above 200W under load. These are all things Intel's tiptoed around with some fantastic pin-point precision engineering. Whether that's a thinner, larger silicon die or over-engineered VRMs and MOSFETs on the motherboard, the Core i9-10900K is a guaranteed titan of a flagship, as long as you can keep it cool and fed.

GPU

Zotac Gaming GeForce RTX 2080 Super AMP Extreme

$1,349

Next up on the chopping block for our no-holds-barred Comet Lake PC is the graphics card. This time around we've gone with Zotac's incredibly beefy RTX 2080 Super AMP Extreme edition. Currently unavailable due to high demand, it packs in some incredible performance at 1440p and 4K, and this model even clocks higher than its big graphical brother the RTX 2080 Ti.

On top of that, you get one heck of a cooler. No seriously, it's massive: This is by far the biggest graphics card we've ever seen, measuring in at 12.8 x 5.4 x 2.3 inches across its massive 2.5-inch PCIe slot bulk.

"This time around we've gone with Zotac's incredibly beefy RTX 2080 Super AMP Extreme edition. Currently unavailable due to high demand, it packs in some incredible performance at 1440p and 4K, and this model even clocks higher than its big graphical brother the RTX 2080 Ti."

MEMORY

32GB (4x8GB) Corsair Dominator Platinum RGB White @ 3600 MHz

$519

OKay, with this build we're actually not aiming to hit a specific price point here. In fact what we're secretly trying to do is use this as an opportunity to pit Intel's Core i9-10900K 10-core processor against AMD's Ryzen 9 3900X in a fair fight. *APC*'s 3900X currently lives inside one of our liquid-cooled builds, complete with 32GB of G.Skill Trident Z RGB DDR4 @ 3600, and features twin EVGA RTX 2080 Super XC Ultras (a quick SLI disable will solve there being two of those).

Now because of that we needed some high-spec memory to match our Ryzen build. When Corsair offered us its latest unreleased Dominator Platinum RGB White kit at 3600MHz, we knew we had to pull the trigger. It's not a cost-effective solution, and Intel's architecture doesn't particularly benefit from the higher speeds, but it will ensure it's a fair contest when it comes to video rendering.

"When Corsair offered us its latest unreleased Dominator Platinum RGB White kit at 3600 MHz, we knew we had to pull the trigger."

MOTHERBOARD

Gigabyte Z490 Aorus Pro AX

$499

For our motherboard we've gone with Gigabyte's Z490 Aorus Pro AX ATX board. It's a well-rounded and almost affordable mid-range motherboard, perfect to house our Intel Core i9-10900K. It comes with memory support for up to 128GB of DDR4 @ 5000MHz, features 2x M.2 PCIe 3.0 connectors, and also bundles in Wi-Fi 6, and an Intel 2.5Gb/s lan port too.

As well as featuring a handy amount of connectivity, it actually looks good. Gigabyte has come a long way from its early Aorus days, and the subtle branding, lightweight fonts, black brushed aluminum, and dare-we-say-it tasteful RGB choices make this a real contender for those looking to build a Comet Lake system.

STORAGE

1TB Corsair Force MP510 M.2 PCIe 3.0 SSD, 2TB WD-Black SN750 M.2 PCIe 3.0 SSD

$739

One area where we couldn't quite keep up with AMD for this build was storage. This is one of the bigger caveats of running Intel right now. We still don't have access to PCIe 4.0, despite the fact that we have a new socket, and the chipset (and some motherboards) have it already onboard for future-proofing.

To that end, we've gone with two hefty drives to back up that performance loss. For our primary OS drive, we've opted for a 960GB Corsair Force MP510, and for our secondary drive we've gone with the equally impressive WD Black SN750 in a 2TB capacity. Despite being perhaps considered a lower quality drive, the MP510 packs in random 4K figures much higher than that of the SN750. Ultimately, however, both of these drives will provide us with some nippy performance for transferring those hefty files around when working with video content. Once the content's produced, in a system like this you could theoretically hold it on the 2TB SN750 until it's been used or uploaded, and then move it onto a home NAS device.

"Despite being perhaps considered a lower quality drive, the MP510 packs in random 4K figures much higher than that of the SN750."

COOLING

EKWB EK-AIO 360 D-RGB

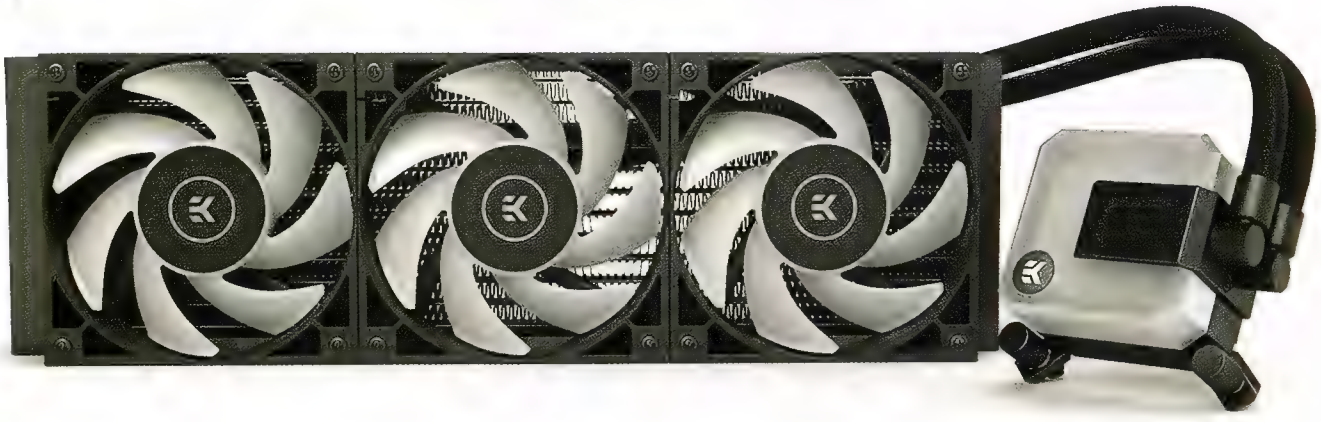
$229

To cool our mighty setup, we've opted for EKWB's EK-AIO 360 D-RGB. We're starting to see a lot of triple-fan 360mm AIO designs pop up out there, but this is one of our favorites, as it's so different from what we've seen from other manufacturers.

The CPU block features a clean frosted-acrylic design, the included fans are the older style RGB Vardars, and it's just a nice piece of kit to have in your build.

It is a touch on the pricey side, but it features compatibility with every motherboard manufacturer out there, comes with a five-year warranty, and is impressively simple to install, although more on that later.

"It is a touch on the pricey side, but it features compatibility with every motherboard manufacturer out there, comes with a five-year warranty, and is impressively simple to install, although more on that later."



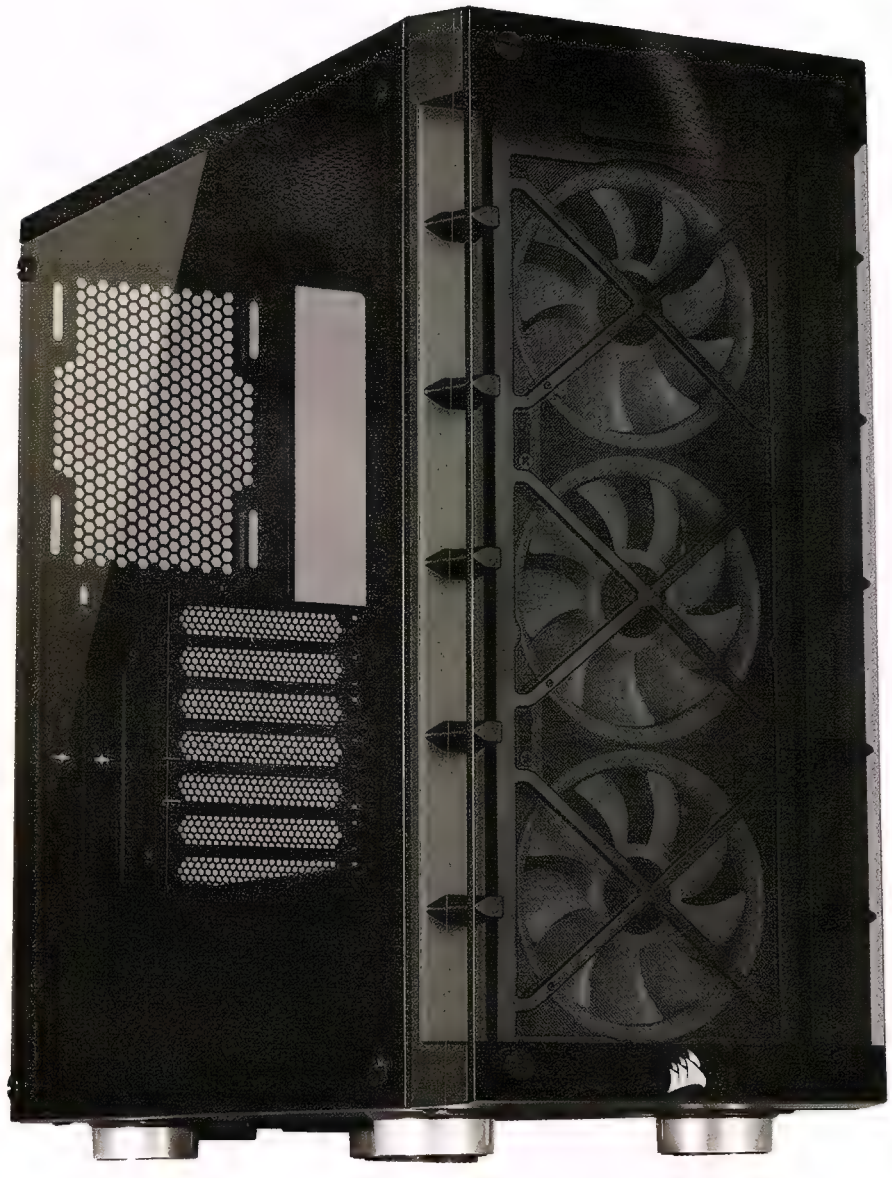
POWER SUPPLY

750W Corsair HX750i 80+ Platinum

$357

Our power supply for this build is actually one we're going to be using for our case review-testing going forward: The Corsair HX750i 80+ Platinum. This fully modular PSU features a zero-noise fan curve, alongside a stonkingly good efficiency and full modularity. We've also coupled it with a set of Corsair's Pro series black sleeved cables to give everything a bit more of a premium feel.

Under load we're expecting this system to pull anywhere between 500-600W from the wall, so hitting that 75 percent load on the power supply should give us close to perfect overall efficiency, both in terms of heat and wasted energy.



CASE

Corsair iCUE 465X Mid Tower

$249

When it came to the case we knew we wanted to take a look at Corsair's latest iCUE 465X RGB, but it comes with a slight hiccough. All in all it's a fantastic chassis for the build, especially with a few tweaks to the intake airflow (although more on that later), but the big problem we have is the price, combined with those front fans. Because we're using the EK-AIO for our build, we'll need to install the 360mm radiator in the front. That works out fine, but the iCUE 465X's party piece is the three included LL120 RGB fans, hooked up to an internal RGB controller.

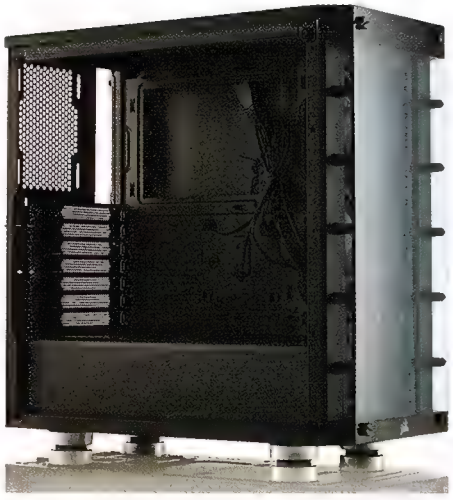
In our system we ended up removing these and not using them. However, this was more of an aesthetic decision than an outright logical thermal one. The thing with that is we're then spending cash on three fans we're not actually going to use, and sadly Corsair doesn't offer a variant of the 465X sans colourful fans, which is annoying.

BUILD IT

Building the Comet Lake Champion

Delving into the murky worlds of RGB, gaming, and rendering glory.

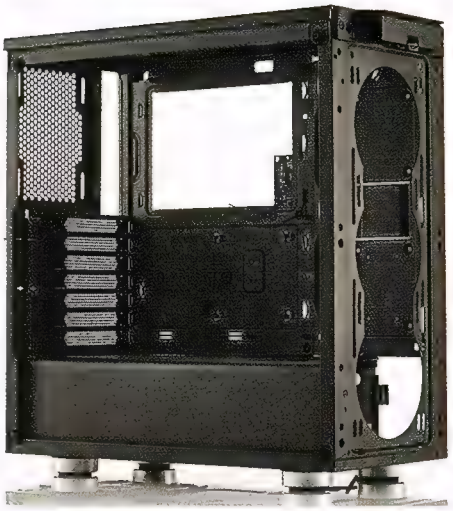
Length of time: 1-2 hours | Level of difficulty: Easy



01 UNBOX THAT CASE

So here's our first look at the Corsair iCUE 465X RGB, with the side panel off. It's not a bad layout at all – it's nice to finally see Corsair fully embrace the full-length PSU cover, as opposed to what the company had been doing with the three-quarter length adjustable plastic – and there's some seriously good ventilation for that front panel as well.

What's up for debate? Well that front fan filter for one thing. The cross-pattern lining is just a bit ugly and boring in our eyes, and as dust filters like this typically hinder airflow significantly, the first thing we'll be doing is removing it.



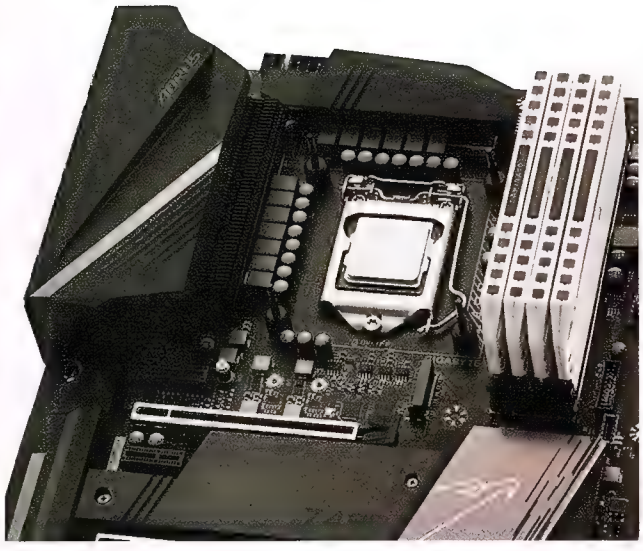
02 TEAR DOWN

The first thing on the list is to remove as many panels as we can. The front tempered-glass panel comes off easily enough; undo the four lengthy thumbscrews (one in each corner), then the entire front section can be pulled away from the case itself. Easy as pie. We'll also remove the three front intake fans here as well, being careful to unclip them from the RGB controller in the back of the case, and remove the dust filters all round.

One thing we're not doing at this stage is removing that bottom-most hard drive cage. In hindsight we should've done that, but more on that later.

03 INTEL'S LGA1200 SOCKET

Intel's latest 10th-gen processors feature a new socket. LGA 1200 increases the size of the overall socket and the CPU itself. This has been done primarily to give Intel room to spread the CPU die out further, effectively using a thinner, wider die to dissipate more heat across a larger surface area, which in turn has allowed Intel to increase core count and clock speed without running into thermal bottlenecks so often. The cooler mounting points are in the same position as they were before, so any old AIOs or fan towers you're using should fit fine. The installation process is also much the same as it's always been; lift the retention arm, identify the gold triangle on the CPU (bottom-left corner), gently place the processor in, resecure the bracket, and pop the retention arm back into place. The plastic cover will then pop off.

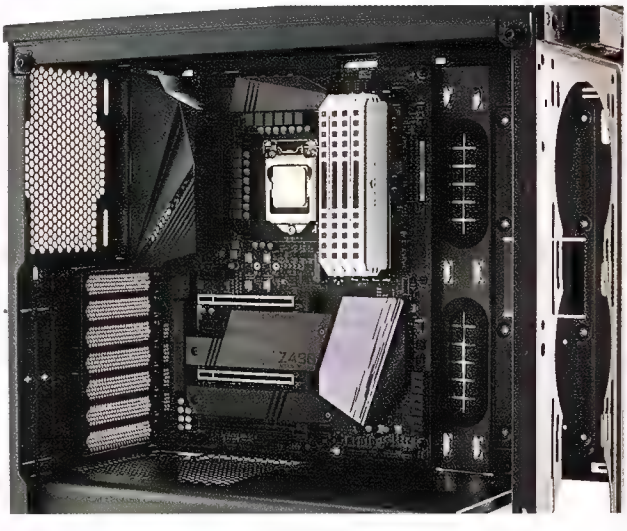


04 DDR4 INSTALLATION

Here we've got our first look at Corsair's white Dominator Platinum RGB DDR4. This special-edition memory looks killer, and those high frequencies should ensure we have a fair playing field with our comparative build. Although the CPU architecture doesn't benefit in the same way as Ryzen does with higher frequencies, in video-editing tasks the faster your memory is the more bandwidth you have, and the quicker you can render those video files.
To install, lift up the tabs at each end of the DDR4 slots on the motherboard, and carefully slot the sticks into position, making note of the offset notch on each RAM stick and the DIMM slot. If using fewer than four sticks of memory, refer to your motherboard manual as to which slots you need to install your memory into.

05 M.2 STORAGE INSTALL

If you can afford it and have support for it, we'd recommend you opt for M.2 storage over everything else outside of backup hard drives (even then, you're probably better off going with a local NAS storage solution). The reason being is they remove cables and clutter, improve airflow in your chassis, and can be hidden out of sight. We're hiding these drives under the Gigabyte Aorus Pro AX's massive M.2 heatsinks located between those three PCIe slots. To install, remove the heatsinks, carefully remove the 2280 M.2 screws, note the notch on the M.2 socket and your M.2 drive, slide them into position, and resecure them down using the M.2 screws. Then reinstall the motherboard heatsink, making sure to remove any plastic film on the thermal pads first.



06 MOTHERBOARD IN

Now that we've got our motherboard prepped, it's time for it to go in the chassis. One thing we forgot to mention earlier (darn word counts getting in the way) is that we've also pre-installed the EK-AIO's mounting backplate to the board itself. It's simply a case of identifying the four long thumb screws you need for your socket, lining up the included backplate, and installing it by hand. To install the motherboard, carefully place it in the case – it's best to have the system laying flat on a table when you do this – line it up with the motherboard stand-offs, then secure it using the included screws found in the case accessories box located in the hard drive caddy.

07 360MM AIO COOLER PREP

At this point we're going ahead and prepping the cooler itself. The EK-AIO comes as standard with pre-applied thermal paste, but as we're not a fan we're wiping it off with a Noctua thermal paste cleaning wipe (isopropyl alcohol will also do the trick), and installing the Intel LGA bracket. It's a simple process; find the two brackets included in the cooler box, and the four screws. Slot them into position, making sure the folded edges are facing downwards, and secure them with the four Phillips screws. If we were mounting this in a pull configuration, with the fans on the inside, we'd install the EK Vardar 120mm fans now too, using the longer screws designed for the radiator. However, for this build, we're going to use the fans as a pushing intake, situated at the front of the case, so we can leave this until the next step.

08 FAN INSTALLATION

Now the cooler's all prepped and the mounting mechanism ready on the motherboard, it's time to mount the radiator and the fans to the case. Carefully slide your radiator into the front of the chassis, then place a 120mm fan in the bottom segment, making sure you orient it so that the cables are facing toward the rear of the chassis. Once in, pre-thread those same cables through into the back of the case for cable management later on. Then, use the included long-threaded screws to go through the fan-mounting locations and into the radiator screw threads. Only install two per fan, in a diagonal pattern, and don't secure them all the way down until all three fans are in. This gives some slack to fit the last two fans, without there being too much tension. Once all three fans are in, tighten the screws, and install the remaining ones.

09 THERMAL PASTE APPLICATION

Oh boy, where to begin with this one? The amount of thermal paste you use isn't that important, as long as you're using the bare minimum. What's the bare minimum? For an Intel LGA1200 processor, a pea-sized dot will do; for Ryzen, you might want to bump that up a bit. Alternatively, using more isn't necessarily a bad thing, unless your paste is conductive, at which point if you get it on the processor's PCB or the motherboard itself you could end up with a shorted processor. Pro overclockers often dump an entire tube of thermal paste on top of processors when they're competing at events, but the best advice for the average person is to aim for that lower amount and you're good. The pressure from the CPU block itself (especially on these smaller chips), will spread out the paste and ensure you have good contact across the entirety of the block.

10 CPU BLOCK INSTALLATION

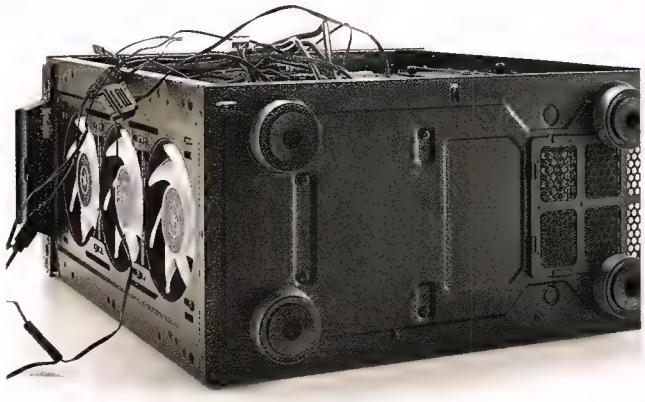
it's now time to install the block. Carefully place your block on top of the CPU, then use the included thumb screws to secure it. Do this in a diagonal pattern – install the bottom-left thumb screw, then the top right, then bottom right, then top left, tightening each a little bit at a time until you reach the end of the thread. This ensures you're not putting too much pressure on one side of the processor during the install, makes it easier to install the thumb screws, and doing it by hand means you won't overtighten and potentially damage the processor's PCB. Once that's done, plug the pump's fan header into the motherboard, and with the EK unit, its D-RGB header too. Our EK block looks really clean unlit like this. The tubing is a bit tight, but we've been told this is due to the fact EK reinforces its tubing with a protective internal sleeve to prevent against long-term wear and tear.

11 FRONT-PANEL HEADERS AND FANS

As this build is going to be fairly intense when it comes to lighting we're not going to worry too much about installing any other front-panel header cables other than the power switch itself. Everything else, aside from USB and audio connectors, is superfluous. On top of that, we've decided to connect all three of the front intake fans into the headers on the bottom of the board here. The EK cooler does come with a three-way to one-way connector, but we're big fans (ha!) of having control over each individual fan in our build; that way, if need be, we can dump more cool air directly onto our GPU, and then run the top two fans quieter if we so desire.

12 THE MONSTER GPU

Can we appreciate how massive this graphics card is? It's ridiculously big, and comes with a serious triple-fan cooler and twin 8-pin PCIe power connectors. It makes its competitor GPU situated in the comparison build – the EVGA RTX 2080 Super XC Ultra Gaming – look puny. The big downside? That GPU sag. It's real, and it doesn't look that great. You can buy support bars to install underneath a card like this, but we find that it detracts from the overall look. Alternatively, some Phanteks cases come with a rear-sided motherboard bracket that helps to reduce GPU sag as well. Either way, it shouldn't cause any major problems, but it does look unsightly.



13 POWER SUPPLY WOES

Now to tackle the power supply and cabling. The Corsair iCUE 465X is what you'd expect for a mid-range tower – short and sweet, in length anyway. It's designed for mid-range products, including power supplies, so it's difficult to fit our full-length PSU in (it's around 18cm in length), especially with the cables pre-installed. You could easily install it without the cables attached, and then try to install them afterwards, but since we're not using the hard drive caddy at all in this build, we thought heck, let's just remove it. To do that you need to turn the case on its side and remove the four Phillips screws from the base, and one attached to the back of the motherboard tray, then slide the hard drive cage along to the back where the power supply will be situated, and pull it out. Then just install your power supply, sorting out the remaining cabling situation, and you're good to go.

14 ALL WRAPPED UP

we didn't have a chance to configure all of the RGB in this build before taking the final shots (photography time is limited in this era of lockdowns), so some of the components are set to rainbow mode, and some are connected directly to the Gigabyte motherboard (namely the EK cooling), which defaults to orange, but it looks darn cool. You'll note we've omitted that front fan filter. This does two things: Firstly, it means we are inevitably going to have to dust the interior of the case a bit more often than before, but more importantly it improves airflow significantly compared to running the chassis with it in place (we've got a feature coming up on that soon). Also, it removes that gaudy criss-cross pattern from the front of the 465X.

The new rendering king?

And there you have it folks, one crisp, clean, overly expensive, armoured-to-the-hilt Intel Comet Lake build, complete with 3TB of storage, 32GB of DDR4 @ 3600MHz, and 10 of Intel's finest 14nm++ cores.

On the whole the build experience was very enjoyable; working in the Corsair iCUE 465X, despite first impressions, was a smooth ride with no major complications. Even afterwards, when we had to do a bit of troubleshooting to diagnose some suspect memory problems (reseat the CPU, it's always reseat the CPU), the case provided us with no issues whatsoever.

And with that front criss-cross fan filter out of the way, this thing just looks killer. Corsair, if you're reading this, you need to pump one of these out in an ITX form factor for sure – 240mm AIO support in the front, 2 x 120mm fans in the roof, and a vertical GPU mount would be a fantastic case. For a mid-tower though? It's not half bad either.

Taking on the Ryzen

Okay, enough, let's get down to the brass tacks here. The big question we want to know is whether Intel's latest Comet Lake flagship can keep up with AMD's Ryzen 9 3900X. It's a tough competition. On the one hand, you have our Ryzen competitor with 12 cores, 24 threads, a whopping 68MB of cache, and a fairly solid 4.6GHz max turbo speed (or 4.2-4.3GHz across all cores), combined with a fairly decent stock cooler, available at just $839. On the other side, Intel's Core i9-10900K comes with 10 cores, 20 threads, 20MB of "Smart Cache," and a phenomenally impressive 5.3GHz max clock speed (which again is around 5.0-5.1GHz across all cores), all for $999. You don't get a cooler with it – but to be fair, even if you did, if you were to buy either of these chips, we would wholeheartedly recommend that you pick up an after-market cooler anyway. So ultimately then, Intel is down on thread count and cache, but higher on the pure grunt that is single-core IPC and clock speed.

We should explain our testing methodology here too. Our comparative system, outside of storage, is very similar. It's actually the 4K Gaming Monster we did last year, but with different memory and one of the RTX 2080 Supers disabled in all of our benchmark tests. Yes, it's liquid cooled, allowing GPU boost and AMD's PBO to work their magic, but on the other hand the GPU follows a basic PCB power design and has lower advertised clock speeds than our Zotac RTX 2080 Super in this build.

On top of that, we're also bringing in a few additional CPU tests to give you a better idea of which platform performs best. There is, of course, more synthetic tests courtesy of Cinebench, TechARP x264, and Fry Render, and additionally we've added two real-world tests, thanks to Adobe. Yes, we'll be putting both processors through their paces by getting each system to render a bespoke five-minute 4K video in Adobe's Premiere Pro CC, using the H.264 codec and the YouTube 4K preset.

Furthermore, we've also put together a short-but-sweet Adobe After Effects video intro, which again we are going to get both machines to export in 4K, but this time under the AVI file format.

"Okay enough, let's get down to the brass tacks here. The big question we want to know is whether Intel's latest Comet Lake flagship can keep up with AMD's Ryzen 9 3900X. It's a tough competition."

The Results

Boy did we get some interesting figures from this. Straight out of the gate in our synthetic tests the AMD comparison system hammered Intel in Cinebench R15's multi-core tests, and we've got to admit, at 192 points, its single-core performance was impressive as well, albeit still not a patch on the Core i9's 225. It also beat the Core i9-10900K in TechARP's x264 benchmark, too. However, this is where things get interesting: In Fry Render Intel won the competition by a single second. That doesn't sound like much, but this is a rendering test, and Intel is down by four threads.

Moving on to the memory tests, and things fall where we'd expect them to. Latency-wise, Intel always edges out AMD, quite substantially. In part we believe this is down to the fact that AMD's core complexes (each one housing four cores) have to communicate with each other and the memory when processing requests, and because of that there's a small delay added on to the latency. It's an architectural difference that's difficult to get past. With Intel and its monolithic design, latency remains consistently lower, and has done since the days of Skylake.

Interestingly, despite both platforms supporting dual-channel DDR4, and both systems using 3,600MHz kits with a C18 latency, the Intel system falls behind in pure memory bandwidth, coming in almost 4,000MB/s lower than its AMD rival. We can only put this down to

APC LABS BENCHMARKS

Indicates best result

	Cinebench R15 Single	Cinebench R15 Multi	TechARP x264	Fry Render	AIDA64 Memory Bandwidth	AIDA64 Memory Latency	SSD 1: CrystalDisk QD8 Sequential Read
	Index	Index	fps	m:s	MB/s	ns	MB/s
Comet Lake PC	225	2,590	56.20	1:16	51,195	50.5	3,352
Zero-point	192	2,952	61.08	1:17	55,051	71.4	4,992

Our zero point consists of an AMD Ryzen 9 3900X, 32GB (4x8GB) G.Skill Trident Z RGB Neo @ 3600, an EVGA GeForce RTX 2080 Super XC Ultra, and a 1TB Corsair Force MP600 M.2 PCIe 4.0 SSD. All game tests were performed at 3440x1440 on Ultra.

01
EK's really nailed it with the styling on this CPU block. The EK-AIO looks incredible, with or without lighting.

02
There's no doubt that this graphics card needs a support bracket or something to help keep it up, if only for our soul.

03
Corsair's latest Dominator Platinum RGB white edition memory looks utterly sublime, although we do wish it'd go back to the single-light top strip.

04
If you can, remove dust filters from the front of your intake fans. It might increase the number of PC cleans you need to do, but your thermals will thank you.

early teething issues with the motherboard BIOSes themselves, as the results should be very similar.

And now we get to the real-world tests, and this is where things really get shaken up a bit. Let's keep this brief. 4K Premiere Pro video export? AMD, nine seconds faster. 4K After Effects video render? Intel, one second faster. It's genuinely impressive.

Despite the extra cores, the extra cache, the synthetic tests showing that AMD had the advantage when it came to memory bandwidth, Intel's single core (and likely Adobe optimisation) managed to narrow the gap significantly.

It's nothing short of awesome, especially when that processor is effectively four threads down on a fight like that.

Wrap-up

So in conclusion, it's a tough one to call. In real-world scenarios, the two processors are neck and neck. Seeing them that close to one another despite the differences is just remarkable, especially given how long Intel's been on that 14nm manufacturing process. However, it's still hard to deny just how much AMD has the advantage in terms of cost to performance. For most of those challenges, it was still either on par or beating a CPU from the competition that costs $160 more than it does. And on top of that, it supports PCIe 4.0 storage as well, on a very mature platform. And as you can see from those results, the differences as far as storage goes are staggering. If you're moving big files around on a day-to-day basis – which let's face it, is very common with video-editing – AMD's offering is still by far the better value choice.

That said, you have to admire Intel for what it's managed to achieve with this. A lot of engineering work has gone into making sure that its 10th generation is still competitive, despite the fact it's based on a five-year-old architecture and a six-year-old manufacturing process.

It's a tough one to call. For those of you who do need a fast CPU for work like this, you're not going to be disappointed picking one of these up, but you've got to know that that comes with an extra $160 cost at a minimum, and you lose out on the storage. Yes, you gain in gaming, but that's not for everyone. The smart choice is AMD, for sure, every time, but there's no denying that the Core i9-10900K is still one killer chip. ■

APC LABS BENCHMARKS CONTINUED

SSD 1: CrystalDisk QD8 Sequential Write	SSD 1: CrystalDisk QD1 Random 4K Read	SSD 1: CrystalDisk QD1 RAndom 4K Write	Adobe Premiere Pro 5-Minute 4K Render	Adobe After Effects 10-Second 4K Render	Total War: Warhammer II	3D Mark: Firestrike
MB/s	MB/s	MB/s	m:s	m:s	fps	Index
2,961	54	177	1:28	6:13	65	23,159
4,284	60	220	1:19	6:14	54	21,453

Our zero point consists of an AMD Ryzen 9 3900X, 32GB (4x8GB) G.Skill Trident Z RGB Neo @ 3600, an EVGA GeForce RTX 2080 Super XC Ultra, and a 1TB Corsair Force MP600 M.2 PCIe 4.0 SSD. All game tests were performed at 3440x1440 on Ultra.

QUICK TIPS

APC experts solve computing problems

The *APC* team tackle problems across the spectrum of devices and software we use. Learn a new trick or fix you can use.

Unexplainable data loss

I have an HP Elitebook that is currently fitted with a 2.5-inch SSD as the main Windows 7 drive, and a 1TB mSATA that contains working files and a majority of VirtualBox images as both VHD and VDI files.

I have recently swapped out the 2.5-inch SSD with another one and installed Windows 10 on it, which has gone very smoothly apart from one issue: When I swap back to the Windows 7 SSD I notice that I have lost some VDI files completely, and others have been corrupted.

I have managed to recover some of the lost files from backups and have tried the swap again, and the same thing keeps happening.

What is causing this, and is there anything I can do to stop this? At some point, I will permanently swap the Windows 7 SSD out and use the Windows 10 one, but I'm concerned about data loss on my mSATA. Any help is most appreciated.
STUART MACKEY

APC responds: We posit the theory that the dual-boot setup is the problem. If the problem only occurs after shutting down Windows 10, then it appears that the filesystem on your data drive isn't being unmounted properly, resulting in file corruption. Have you run disk checks on the drive? If problems are found (and subsequently repaired) it would confirm that diagnosis.

If the diagnosis is confirmed, then there's one possible reason: Fast Boot. Windows 8.1 and 10 both utilise this to speed up startup by only performing a hybrid shutdown that combines classic shutdown mechanisms with hibernation. Try disabling Fast Boot in Windows 10 to see if this fixes the issue: Select "Additional power settings" under "Settings > Power & sleep." Click "Choose what the power buttons do," followed by "Change settings that are currently unavailable," then untick "Turn on fast start-up (recommended)" and click "Save changes."

If this doesn't fix the problem, then the Doc wonders if your mSATA drive configuration is to blame somehow. The port is designed for use as an optional flash cache to accelerate performance on non-SSD drives rather than out-and-out storage, so that may be a factor. Think about how you set the drive up initially – with Intel Rapid Storage maybe? If so, it will have set up a cache and then made the rest of the drive available as storage, so perhaps swapping Windows installations disrupts this process and leads to the file corruption you experience.

Again, a disk check should diagnose and clear the problem. It's also worth visiting the drive manufacturer's website to see if you can locate a drive utility that can be used to monitor the drive health and maybe even help reconfigure it if necessary. Ultimately, though, we recommend taking the time to migrate fully to Windows 10 now.

This low-profile cooler is an excellent budget choice for Intel CPUs.

Windows 7 is no longer secure, so if all else fails make the switch, and see how your PC behaves with Windows 10 as its only OS.

CPU overheating

Long-time APC reader and troublemaker here. I have a question about a CPU I'm trying to use, an older Intel 4600k I recently re-seated in an old chassis (Asus H97, Corsair H100i GTX). I didn't bother reapplying thermal paste because it was still intact with the cooler. On firing it up, my CPU temps have doubled from a cool 30/40 C to 60/80 C. All six fans are flowing correctly: Three at the front, two on the radiator, and one on the exhaust chassis. However, my cooling pumps are off – one doesn't seem to be flowing at all, and the other is very hot. I can jiggle the suspect pump and the CPU immediately cools off but cannot correct the issue. Presumably, this rules out the thermal paste and points to a defective cooler?
RYAN PITTS

APC responds: All your symptoms clearly indicate that the cooling pump needs replacing – and the *APC* team have a similar experience to back up that diagnosis too. That said, while the chip is running hotter than you'd like, 60-80 C is within its normal limits – deally it'll stay under 75 C, but unless you plan to push this PC or use it regularly, you should be able to make do with the existing cooling.

Alternatively, look to either apply new thermal paste (a tube of MX-4 costs around $15) or replace your stock cooler with a budget, but effective, alternative like Noctua's NH-L9i low-profile cooler. One reviewer reports having used it for five years on a gaming rig with poor ventilation without ever seeing temps peak above 65 C.

M.2 NVMe vs SATA

I have a Dell 5675 with a Ryzen 7 1800X and am not a gamer. The computer came with an M.2 boot drive – I want to swap it out for an NVMe one, and there is an empty

slot. However, I can't seem to get the computer to recognise the NVMe drive. What am I doing wrong? Maybe the bigger question is: Will I see improved start-up times?
KURT WAGNER

APC responds: The Dell community forums are littered with posts about swapping out the SATA M.2 drive supplied by Dell for a faster NVMe drive. One interesting observation is that the NVMe slot found on your Dell motherboard only supports Gen2 x4 speeds (around 1.5GB/s) – significantly faster than SATA (600MB/s), but half the NVMe maximum (3.2GB/s).

Some Dell users have reported success investing in an M.2 PCIe x4 adapter – plug this into the second graphics card slot and you'll be able to use the PCIe 3.0 bus to boost your speeds to their maximum. Other Dell 5675 users have reported success with a Mailiya model, but we suspect you'll get the same results with the much cheaper Rivo ($15 from **www.amazon.com**).

Once physically fitted, boot into Windows and the drive should be physically visible in Disk Management, ready for configuration. It's worth visiting the drive manufacturer's webpages for any additional software – for example, Samsung Magician for Samsung drives can help you configure, update, and benchmark your new drive. Samsung also provides a data migration tool to clone your current drive to the new one.

Once cloned, you'll need to remove the original drive temporarily before powering back up, and Windows should now boot from the newer drive. Once you've successfully booted once, you can refit the older drive, which will be set to offline due to a signature collision with the newer drive. You can then convert your old drive into a data or backup drive by first wiping it from the command line – see **https://bit.ly/MPCseagate** for a guide – and then setting it up as normal.

As for performance, you're never going to get Chromebook-style boot times of under 10 seconds – even with a quick POST, you're looking at boot times of around 40 seconds to the desktop, plus however long your start-up apps take. But NVMe is significantly faster than SATA, particularly on the PCIe 3.0 bus, and you'll definitely feel the benefit in terms of snappier performance and boot times.

NVMe on PCIe is significantly quicker than SATA.

InstallShield error 628

I'm running Windows 10, 1909 (updated from Windows 7 a few years back). I was trying to install an older chess game from an older laptop, and I received an error message: "Error 1628: failed to complete installation." I've tried every remedy on the internet: Renamed the InstallShield folder, emptied the Temp directory. I've even tried ending the IDRIVER.EXE process via Task Manager, but nothing has worked. Can you help?
JERRY SEMLER

APC responds: Ah, "good-old" InstallShield. The simplest thing to do here is write it off – InstallShield is old tech and a pain in the butt to troubleshoot, as *APC* has found to its cost over the years. Without knowing the exact game, we can't tell you whether it runs in Windows 10 anyway, but one ancient chess game that utilises InstallShield is Chessmaster Grand Edition from Ubisoft. A search of online forums reveals it will work on Windows 10 (after upgrading from Windows 7 at least), but there are compatibility issues.

This might be one of those occasions where exploring an alternative means of running the game may be in order – for example, using virtualisation software like Microsoft's own Hyper-V platform (Windows 10 Professional required) or VirtualBox (**www.virtualbox.org**) in conjunction with a copy of Windows XP, Vista, or even 7.

Ultimately, though, if you rely on InstallShield for any programs still running, then now is the time to investigate a clean reinstall of Windows (particularly if you've not done so since upgrading from Windows 7). InstallShield gets so messed up that it's almost impossible to remove or fix. Then, going forward, get into the habit of taking regular drive image backups of your Windows installation using a tool like Macrium Reflect Free (**www.macrium.com/reflectfree.aspx**), so that when you run into a problem like this in future, resolving it involves rolling back your PC a few days or a week rather than having to reach for the nuclear option.

HDMI voltage bleed

I've seen videos on the internet showing arcing coming from coax, USB, and HDMI cables when they seem to get high voltage between the conductors and ground shells. What advice can you give to avoid burning up expensive equipment due to what seemed to be termed "voltage bleed over" from an offending device's HDMI socket?
STEVE BIGELOW

APC responds: This feels like more of a question for an electrician, but it's basically caused by faulty electronic components that "bleed" out high amounts of voltage through your display's ports. The source may be the display itself, but it may also be caused by another device connected to your display – for example, a TV box.

Electricians use so-called Foreign Voltage detectors to confirm the diagnosis: First, wave this close to the surface of your TV, then hold it close to the tip of an HDMI cable that's only plugged into the TV. The issue can be fixed by installing a grounding module into your electrical outlet, then use coax wire to connect the coax screw on the back of your TV to the coax screw on the unit. ■

Spice up your taskbar with TaskbarX

Alex Blake leaves no tile untweaked.

YOU'LL NEED THIS

TASKBARX
https://chrisandriessen.nl/taskbarx

WINDOWS 10

The Windows 10 taskbar may not be the most exciting thing in the world, but you can give it a healthy dose of visual flair with the help of TaskbarX, an app that makes it easy to center your taskbar icons – and a whole lot more. It works particularly well if you want to have a cleaner, more understated look for your taskbar. Centering your icons with TaskbarX gives a more modern look than the default Windows taskbar appearance, especially if you only have a couple of pinned icons.

You can take things further with some of TaskbarX's built-in options. For example, you can make your taskbar entirely transparent, making your icons appear to be floating against your wallpaper. You can change how your icons animate into position when you open a new app. And it works well if your setup involves multiple monitors, with lots of extra options to customise it exactly how you want. We will take you through the process of giving your taskbar some much-needed love and attention with this handy little program.

Get started

TaskbarX comes in two flavors: A free version hosted on the developer's website, and a version on the Microsoft Store that carries a small fee. Both of these versions are functionally the same, however.

Head to **chrisandriessen.nl/taskbarx** and click "Download Zip," then extract the zip archive to your chosen location. TaskbarX is a portable app and does not have an installer, so double-click the TaskbarX.exe file to run it – you will notice that any icons pinned to your taskbar have now become centered. By default, TaskbarX will now run every time you load your PC. If you want to adjust any of TaskbarX's settings, you need to launch the TaskbarX Configurator. exe file located in the same folder.

Express your style

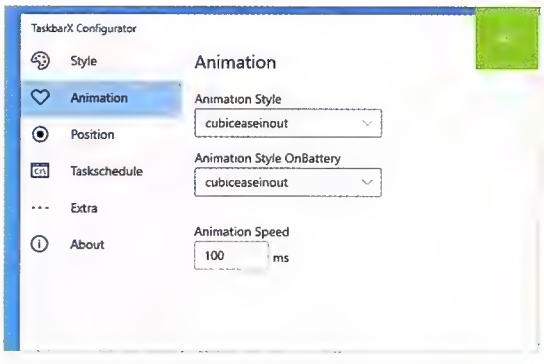
Once you have opened TaskbarX Configurator, you will see several tabs on the left-hand side of the app, starting with "Style." This lets you choose what visual appearance your taskbar will have. The first selection is "Default" – this keeps the taskbar opacity the same as if you were not using TaskbarX.

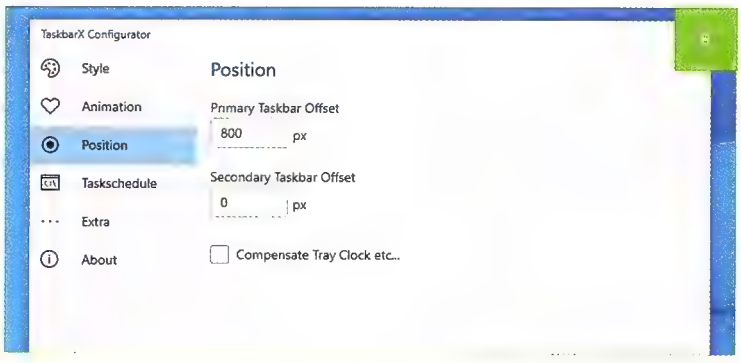
"Transparent" makes your taskbar entirely transparent. "Blur" adds a heavy blur to your wallpaper behind the taskbar while maintaining low opacity. "Acrylic," meanwhile, attempts to replicate the trappings of Microsoft's Fluent Design System. The result is similar to Blur's clouded taskbar, but it opts for a higher opacity level, meaning the edge of the taskbar is easier to see.

After choosing, click "Apply" to make the changes.

Animation effects

Next, click "Animation" in the left-hand toolbar. Whenever you open a new app (and its icon appears on the taskbar), TaskbarX will re-center the taskbar icons to take it into account. The app gives you a vast number of options when deciding what sort of animation to use – there are over 30 animations to choose from [Image A]. To see one in action, select it, then click "Apply;" TaskbarX will refresh, and your taskbar icons will re-center themselves using the chosen animation. Alternatively, open a

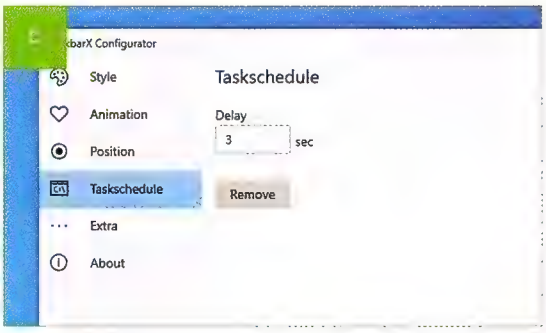




Combining TaskbarX and Windows settings

The visual tricks of TaskbarX can be combined with Windows 10's taskbar settings for some interesting effects. Open the Windows 10 Settings app, click "Personalisation," then click "Taskbar" at the bottom of the left-hand column. Under the "Combine taskbar buttons" header, select "Never" in the drop-down menu to see your icons expand to show window titles as well as icons. Alternatively, enable the "Use small taskbar buttons" setting to save space while still retaining a centered taskbar.

Experiment with different settings here to see what kind of effects you can create using both Windows 10 and TaskbarX. The app is very flexible and accommodates a wide range of Windows 10 settings adjustments. Some changes to Windows 10's taskbar settings may require you to refresh TaskbarX – just click the "Restart TaskbarX" button at the bottom of the Configurator app to see your changes take effect.



new app to see its icon appear in the taskbar using your chosen animation effect.

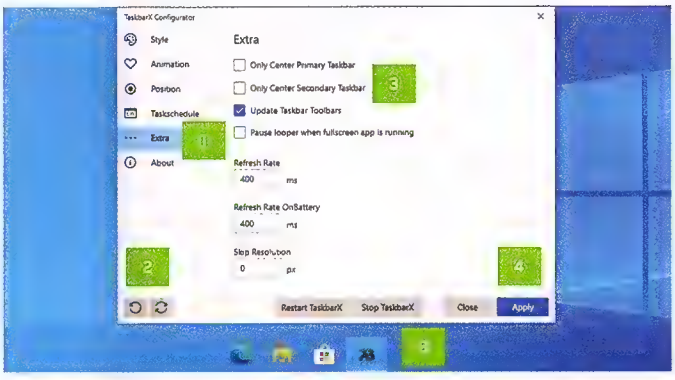
You can select a different animation (or none at all) if your PC is running on battery power as opposed to being plugged in. This is useful if you want to save on tasks that might add extra load to your processor (such as animations) and eat into your battery life.

Finally, you can also change the animation speed in milliseconds. Some animations run very quickly at the default 100ms, so increasing this number can be a way to see the animation in more detail.

Take up a position

With TaskbarX running, your taskbar icons will be centered. You can make some slight adjustments to this, but there is no "left-align" or "right-align" option in the Configurator app. So, what do you do if you want to achieve a similar effect? Well, you can offset your icons. If you want to right-align your icons, enter a large number in the "Primary Taskbar Offset" window. The required number will depend on your monitor's resolution: On a 1440p display, for example, around 800px is enough to right-align the icons [Image B]. To left-align the icons, on the other hand, just enter a negative number, such as -500.

When determining how to center your taskbar icons, TaskbarX measures the distance between the left-hand edge and right-hand edge of your display. However, this does not consider the Windows search box on the left and the notification area on the right, and you may feel that your icons look off-center because of this. To take these into account, tick the "Compensate Tray Clock" checkbox and click "Apply." The center of your display will now be calculated using the right-most edge of the search box and the left-most edge of the notification area.



TaskbarX in action

01 CATEGORISED SETTINGS
TaskbarX's settings are divided into various categories, all of which you can access from this tab.

02 RELOAD AND RESET
Sometimes you need to refresh the app's settings. The left button here resets all settings to default, while the right button reloads the current settings.

03 DETAILED SETTINGS
The settings for each category can be accessed and tweaked in the right-hand panel.

04 APPLY YOUR CHANGES
Make sure to click "Apply" once you have made some changes to ensure that TaskbarX implements them.

05 YOUR MODIFIED TASKBAR
You can see TaskbarX's changes on your Windows 10 taskbar. Here, we have chosen to make our taskbar transparent, alongside the default centering position for the icons.

Taskschedule

When you first log in to Windows 10, a lot of processes start up at once. If you are concerned that TaskbarX could conflict with some of these, or load prematurely – for example, before Windows Explorer has loaded the taskbar – you can delay it from launching immediately using the "Taskschedule" tab.

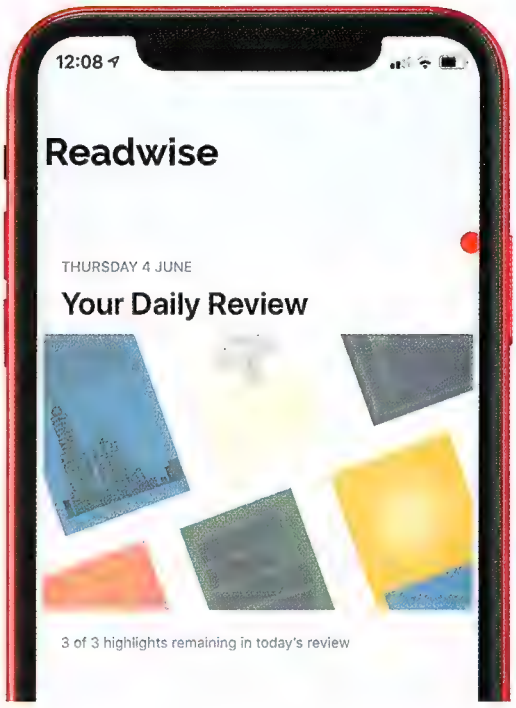
This is set to use a three-second delay by default [Image C]. You can increase this if you like, or remove it entirely if you think there are unlikely to be any issues with it running straight away. We recommend you leave it at three seconds, though, just to be safe.

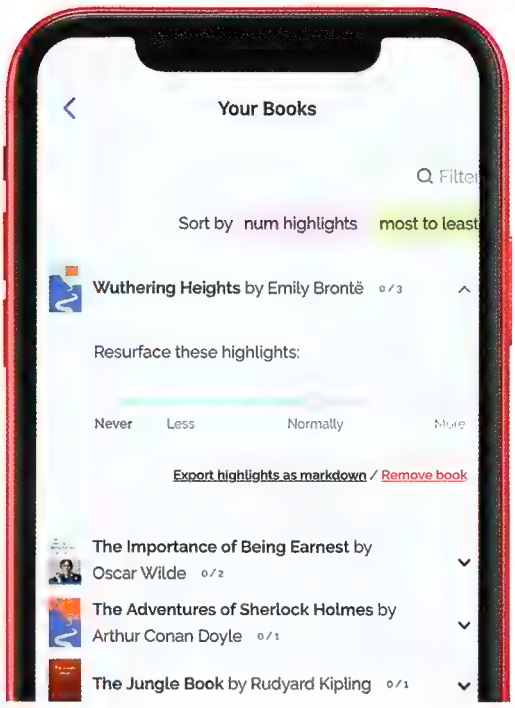
Extra options

There is much more that TaskbarX can do, with plenty of additional settings that can be found in the "Extra" tab. For instance, if you have added toolbars to your taskbar – such as showing addresses or links – then the "Update Taskbar Toolbars" option will reposition your icons accordingly. If you are using multiple monitors, you can also choose whether the taskbar is centered only on your main monitor or only on your secondary monitor.

Further down in the "Extra" tab you can find a few more options. TaskbarX refreshes regularly to detect changes (such as when you add a toolbar), and this refresh rate is set to 400ms. You can adjust this – lowering the number will result in TaskbarX updating more quickly but adds a bit more load to your processor. You can set different refresh times depending on whether you are using battery power, too.

And finally, you can also tell TaskbarX to stop centering your icons and to put them back on the left-hand side if your monitor's resolution width is set to a certain number. ■




Your Books
Sort by num highlights most to least
Wuthering Heights by Emily Brontë 0/3
Resurface these highlights:
Never Less Normally
Export highlights as markdown / Remove book
The Importance of Being Earnest by Oscar Wilde 0/2
The Adventures of Sherlock Holmes by Arthur Conan Doyle 0/1
The Jungle Book by Rudyard Kipling 0/1

iOS

Learn more with Readwise

Organise your ebook highlights and absorb more when you read.

Reading ebooks can be thought-provoking, inspiring, and educational, prompting us to highlight memorable passages and take copious notes alongside them. Before we know it, though, we end up with an unassailable mountain of highlights that sit unread forever, defeating the whole point of saving notes in the first place.

Readwise aims to change that by making highlights much more accessible. Instead of being confronted with a heap of unsorted notes from your favourite books and articles, Readwise 'surfaces' selected quotes in the app and in a round-up email every day, giving you a manageable digest of information that will help you memorise key passages and learn more from the material you have read.

In this guide, we will take you through the basics of setting up and using Readwise, helping you get much more from your reading list than a mere pile of jumbled highlights. It is time to get your ebook collection back on track.

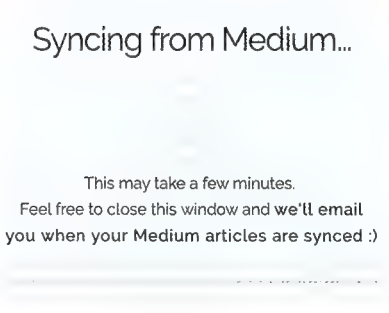
ALEX BLAKE

IT WILL TAKE
20 minutes

YOU WILL LEARN
How to import, memorise and organise ebook highlights

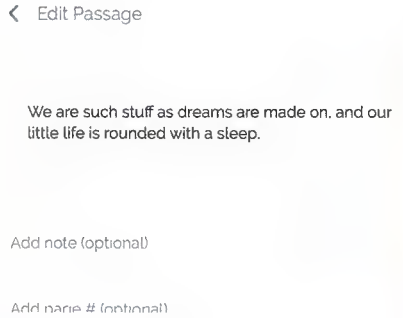
YOU'LL NEED
An iOS device, the Readwise app

HOW TO: Add highlights from your books and articles


Syncing from Medium...
This may take a few minutes.
Feel free to close this window and we'll email you when your Medium articles are synced :)

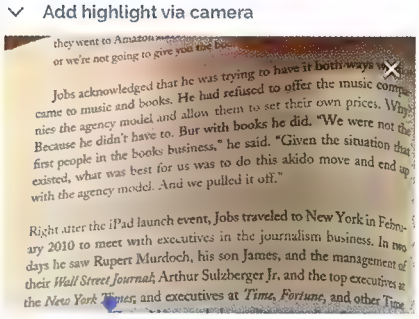
01 CHOOSE A SOURCE

Readwise lets you import highlights from various sources, including Medium, Instapaper, Pocket, and more. Tap Add Highlights, choose a source and log in, then wait for Readwise to sync your notes to your device.


Edit Passage
We are such stuff as dreams are made on, and our little life is rounded with a sleep.
Add note (optional)
Add page # (optional)

02 MANUALLY ENTER TEXT

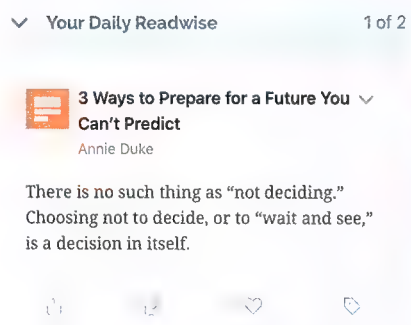
Alternatively, you can manually enter a highlight by typing it. On the Add Highlights page, tap the pencil icon, then type a passage. Tap Next. Add notes and page numbers if you like and assign the highlight to a book.



03 TAKE A PICTURE

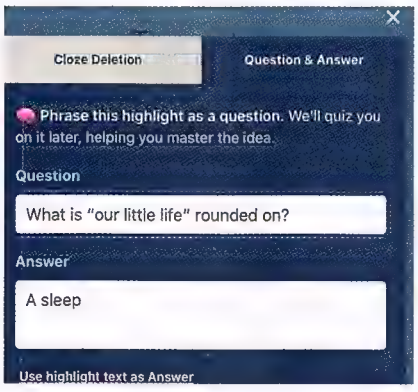
Alternatively, tap the camera icon on the Add Highlights page and snap a passage from a book. Tap the Next arrow and highlight the text to import. Make any corrections, add notes and page numbers, then assign it to a book.

HOW TO: Review your highlights


Your Daily Readwise
1 of 2
3 Ways to Prepare for a Future You Can't Predict
Annie Duke
There is no such thing as "not deciding." Choosing not to decide, or to "wait and see," is a decision in itself.

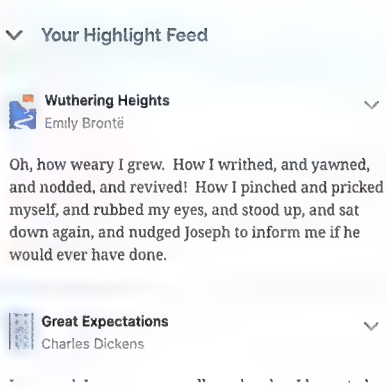
01 YOUR DAILY REVIEW

Tap Review, then tap Your Daily Review. Here you can see recent highlights and share, edit, like or tag them. You can keep them for later or discard them. You can also choose how often Readwise resurfaces each quote.


Cloze Deletion
Question & Answer
Phrase this highlight as a question. We'll quiz you on it later, helping you master the idea.
Question
What is "our little life" rounded on?
Answer
A sleep
Use highlight text as Answer

02 MASTER KEY PASSAGES

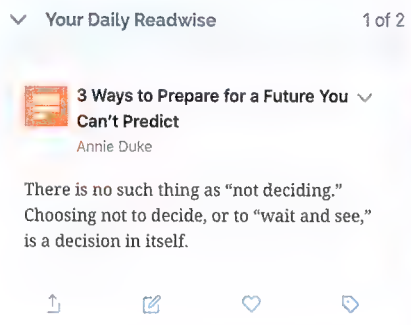
On Your Daily Review, tap Master to turn quotes into flash cards to help you remember them. You can blank out keywords or rephrase the quote as a question that you must answer. Readwise will quiz you on it later.


Your Highlight Feed
Wuthering Heights
Emily Brontë
Oh, how weary I grew. How I writhed, and yawned, and nodded, and revived! How I pinched and pricked myself, and rubbed my eyes, and stood up, and sat down again, and nudged Joseph to inform me if he would ever have done.
Great Expectations
Charles Dickens

03 YOUR FEED

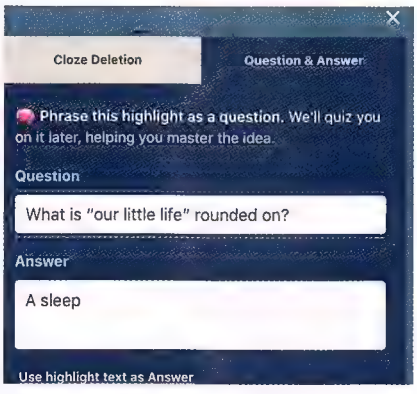
To catch up on your saved highlights, tap Review, then Your Feed. You can browse saved quotes and change how often each book or article is shown to you, if you like. Tap a quote to get the options from step 1.

HOW TO: Use tags to keep things organised


Your Daily Readwise
1 of 2
3 Ways to Prepare for a Future You Can't Predict
Annie Duke
There is no such thing as "not deciding." Choosing not to decide, or to "wait and see," is a decision in itself.

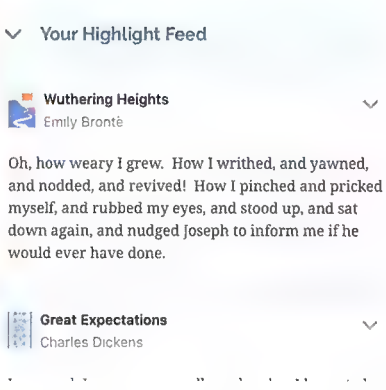
01 CREATE A TAG

Find a highlight in Your Daily Review or Your Feed, then tap it to open it up. Tap the tag button and start typing a tag name. When you are finished, tap 'Create [tag name]'. This will apply the tag to this particular highlight.


Cloze Deletion
Question & Answer
Phrase this highlight as a question. We'll quiz you on it later, helping you master the idea.
Question
What is "our little life" rounded on?
Answer
A sleep
Use highlight text as Answer

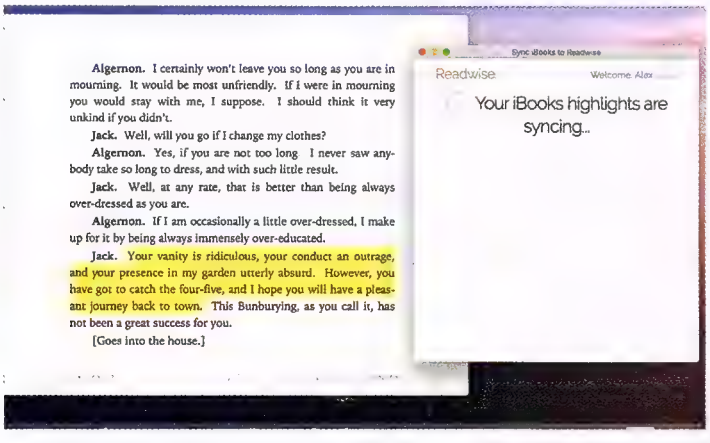
02 FIND USING TAGS

Tap Browse at the bottom of the screen, then tap 'Your tags'. This will list all the tags you have created; tap one to reveal Edit and Delete options, then tap its name to see all the entries that you have organised with that tag.


Your Highlight Feed
Wuthering Heights
Emily Brontë
Oh, how weary I grew. How I writhed, and yawned, and nodded, and revived! How I pinched and pricked myself, and rubbed my eyes, and stood up, and sat down again, and nudged Joseph to inform me if he would ever have done.
Great Expectations
Charles Dickens

03 MERGE PASSAGES

In your ebook reader, add a note titled '.c1' on one sentence, then one named '.c2' on another, then sync your ebook to the Readwise app. The two sentences will be merged into a single highlight for easier viewing.


Algernon. I certainly won't leave you so long as you are in mourning. It would be most unfriendly. If I were in mourning you would stay with me, I suppose. I should think it very unkind if you didn't.
Jack. Well, will you go if I change my clothes?
Algernon. Yes, if you are not too long I never saw anybody take so long to dress, and with such little result.
Jack. Well, at any rate, that is better than being always over-dressed as you are.
Algernon. If I am occasionally a little over-dressed, I make up for it by being always immensely over-educated.
Jack. Your vanity is ridiculous, your conduct an outrage, and your presence in my garden utterly absurd. However, you have got to catch the four-five, and I hope you will have a pleasant journey back to town. This Bunburying, as you call it, has not been a great success for you.
[Goes into the house.]
Sync iBooks to Readwise
Readwise
Welcome, Alex
Your iBooks highlights are syncing...

Export Apple Books to Readwise

Here's how to sync those ebooks

Syncing your content from online services to Readwise is straightforward, but there is one exception that takes a bit more work: Apple Books. First, download the Readwise Mac tool from readwise.io and install it. Launch the app and let it sync your Books highlights and notes. When it is done, open Readwise on iOS and your Books highlights should have appeared. Be aware that if you have saved notes to a PDF using Preview, then imported it into Books, these notes will not transfer to Readwise. You need to make the notes in the Books app itself.

MAC

Enhance images in Luminar 4

Make quick or automatic enhancements to your images with the help of artificial intelligence tricks.

If you're not sure where to start with image enhancement or just want a helping hand, Luminar's AI-powered tools can analyse your image and get you started. The software also features 'looks' which are presets that change multiple aspects of an image from colours, exposure and brightness to sharpness and vignetting. Although other photo apps let you tweak pictures, Luminar is particularly user-friendly and powerful. And if you're a beginner or just in a hurry, its AI features are a great helping hand.

Looks work by automatically dialling in a bunch of adjustments and there's an amount slider so you can choose how strongly the look is applied. In the Essentials edit tab you'll find more quick enhancement tools including Colour, Details and Light all with variable sliders, so you can quickly and easily make your pictures look more vibrant, interesting and professional. It will help to start with a high resolution image, though JPEGs are fine. If you do have the option of working on a RAW file, that will give Luminar the maximum amount of info to work with.

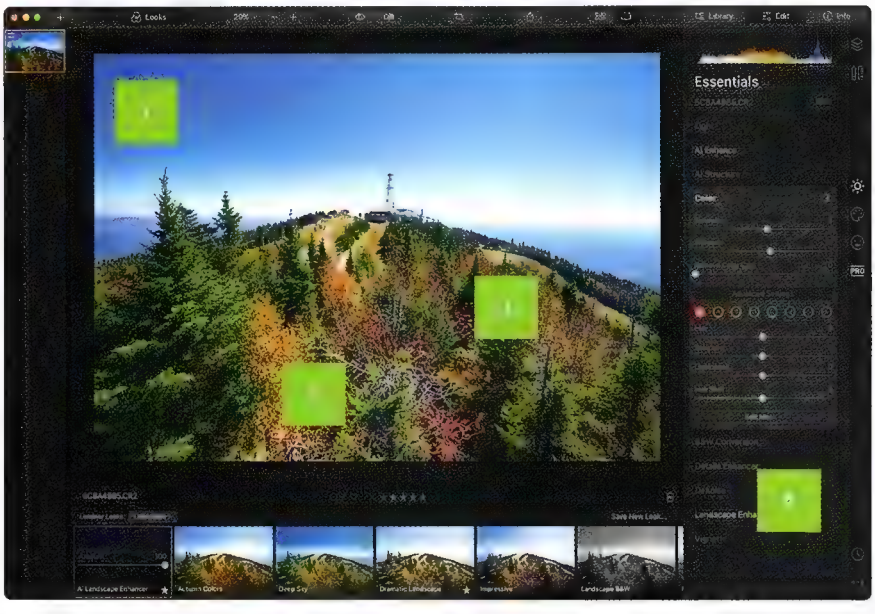
HOLLIN JONES

IT WILL TAKE
10 minutes

YOU WILL LEARN
How to use AI, presets and manual controls to improve your pictures

YOU'LL NEED
macOS 10.12 or later, Luminar 4, high resolution image

Working with Luminar 4



01 VIEW OPTIONS
Zoom in to see details of images and use the before/after controls to check the changes.

02 AI TOOLS
The Essentials section includes AI-powered tools that analyse your pic and make automatic improvements.

03 MANUAL TOOLS
Most tools have manual controls so you can tweak parameters like colour levels, saturation and vibrance.

04 LOOKS
Looks are complete presets that change lots at once. Each has a slider so you can apply as much as you like.

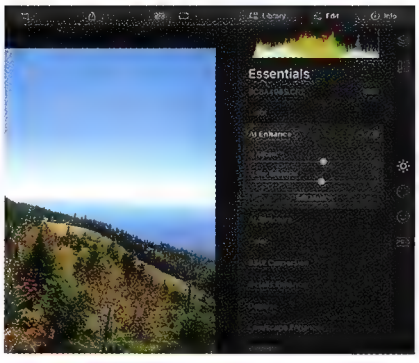
HOW TO Quickly enhance an image

01 LOAD YOUR FILE

Load an image using the Add button or File menu. You can load a folder of images or work on one at once. Here we have a Raw file that has no edits – it's just as it came out of the camera, and needs some work.

02 APPLY A LOOK

Press the Looks button at the top to reveal the Looks panel, then choose a set appropriate to your image. In this case, it's Landscapes. Select a look to apply it and then use its slider to apply any amount you want from 0 to 100%.

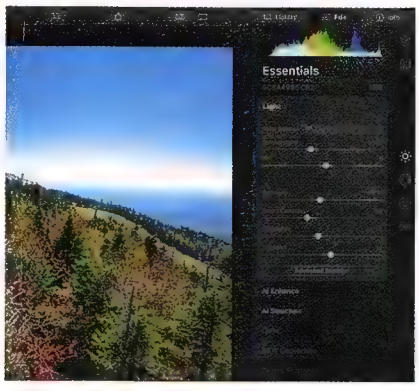


03 TRY THE AI

control-click on the image and choose Adjustments > Reset Adjustments to remove the look. Now go to the Essentials section to the right and the AI Enhance tab. Raise the two sliders to somewhere around halfway.

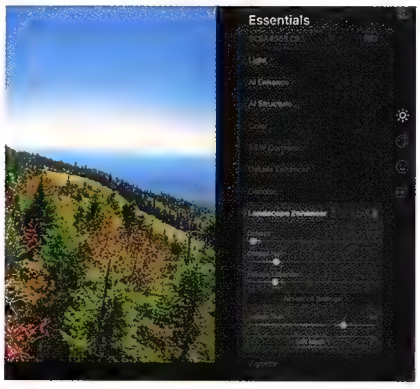
04 ADD DEFINITION

Move beneath, to the AI Structure tab and repeat the process. Luminar's algorithms analyse your picture and alter it based on its best guess. You can use the Before and After toggle at the top to see what changes are being applied.



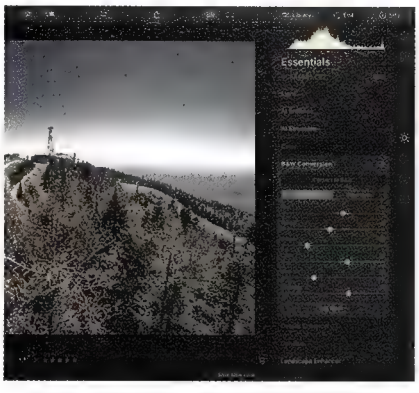
05 WORK WITH THE LIGHT

Now move to the Light tab in the Essentials section. Since this is a bright scene, we'll need to reduce the exposure and contrast slightly. Each image will require its own treatment, and a darker image may need these sliders increasing.



06 LOVE YOUR LANDSCAPES

Move down to the Landscape tab. The Foliage Enhancer can be used to make plants and trees more vibrant, and if you click on the Advanced button you can even choose which shade of green you want to enhance.

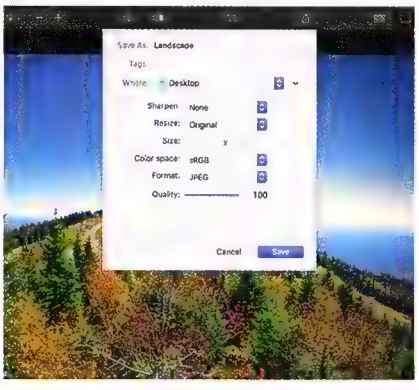


07 GO BLACK AND WHITE

For a different feel, select the B&W Conversion tab and click Convert. Now you get some colour sliders, but in this mode they change different black, white and grey tones within the image. Experiment to see how they affect yours.

08 REVERT TO COLOUR

You can use Edit > Undo to revert to a colour version. Go to the Vignette tab and choose Amount and Size settings. Vignetting adds black or white fades in the corners to focus the eye on the centre of the image.



09 EXPORT YOUR IMAGE

When you're done, go to File > Export and choose a destination and a format. A high quality JPEG is a good choice for email or the web, or a TIFF file if you intend to print it. You do have the option to resize and compress images.

LINUX

Multi-user task and project management

Nick Peers reveals how to manage everything from simple to-do items to complex multi-user projects with this clever Wunderlist-replacement.

Fans of the Wunderlist cloud-based task manager will by now know that Microsoft has finally pulled the plug on the venerable service, which was launched in 2011 by a German company (Wunderkinder) before being bought by Microsoft in 2015. Users were directed instead to switch to Microsoft's own To Do application, but while it retains many of Wunderlist's features, it's not the same experience – plus there's no official client for Linux.

Thankfully, project management specialist Zenkit has spied an opportunity and developed its own Wunderlist clone. Zenkit To Do mirrors the Wunderlist experience as closely as possible, aiming to replicate not just its look and feel, but the feature set, too. The application harnesses the Zenkit eco-system to provide a cut-down version of its main offering, with the promise of more to come in the months ahead. Unlike Wunderlist, not all its functionality is free, but the free tier offers more than enough for most people and that's what we're focusing on in this tutorial.

Very flattering

Anyone familiar with Wunderlist will appreciate just how brilliant Zenkit To Do is the moment that you first log in. You'll have access to virtually the same feature set in Wunderlist – namely the means to create to-do items and organise them into lists and folders. Each item can be assigned deadlines and reminders, support multiple subtasks to help you manage more complicated projects and be assigned notes and file attachments. Like Wunderlist, you can also collaborate with other Zenkit To Do users – assign family, friends and co-workers tasks, receive notifications of changes to documents, open a chat window to discuss the current project and more besides.

To see how closely Zenkit To Do mirrors Wunderlist, visit **https://zenkit.com/en/todo/switch-from-wunderlist** where you'll discover that Zenkit To Do has some nifty features of its own not found in Wunderlist: HTML and markdown formatting of notes for starters, plus two-factor authentication (2FA) support to add another layer of security to your account.

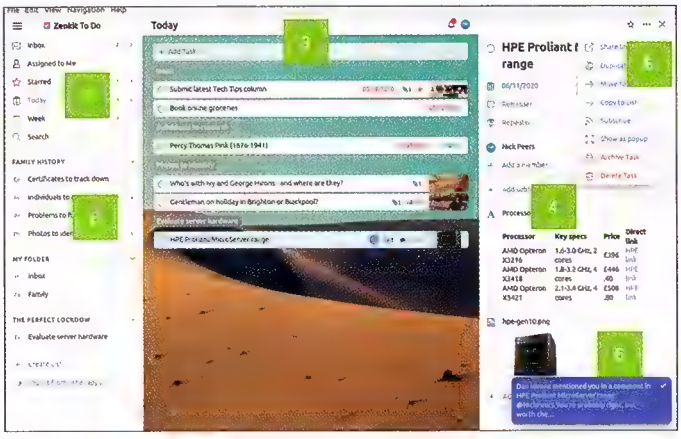
QUICK TIP
By default, lists are shown with a small icon denoting the first two letters of the list name – you'll need a Plus subscription to change this for a custom icon, but you can at least change the icon colour and background colour for free – right-click the list name and choose Settings.

Like all good cloud services, Zenkit To Do is accessible across all major platforms as well as through the web. Unlike Microsoft To Do, Zenkit's offering includes a fully functional Linux program.

It mirrors the web-based interface, but stores your data locally (with your permission) so you can access and update your projects offline before syncing when you're next connected.

Enter the Zen zone

Zenkit To Do is available via snap, so can be installed directly from the Ubuntu Software Centre in Ubuntu 20.04. More download options – including the portable AppImage format – can be found on the program's platforms page. See what's available by visiting **https://zenkit.com/en/todo/platforms**).



01 NAVIGATION PANE
Quickly track down the to-do item you're looking for with the help of smart lists and a search tool.

02 TASK ORGANISATION
Use this to organise your tasks into lists and folders to turn simple to-do items into a full-blown project.

03 CURRENT VIEW
Select a smart list or list from the navigation pane to display all the tasks that are related to it here.

04 EDIT PANE
Click a task to edit it and record extra details, plus make comments, and review all the task's activity.

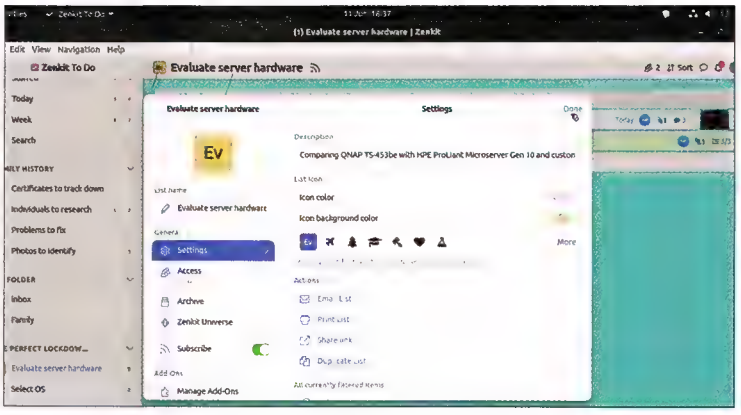
05 TASK OPTIONS
Click the ... button to access additional tools, including an option to view the Edit pane as a floating window.

06 STAY NOTIFIED
Toast notifications are just one of the ways that Zenkit To Do can be configured to alert you.

Once installed, launch the program. Start by either signing up for a new free account or signing into an existing account. You can sign up via various third-party services, but as always the most secure option is to create a dedicated user/password combo following the usual good practice.

After signing up, you'll need to confirm your account via email – click the link and you'll be logged in through your web browser. Close this and return to the application where you can now log in. You'll find yourself at the Zenkit To Do 'Inbox', which is basically like your email inbox. Use this to store to-do items that pop into your head before either clearing or filing them later.

If you're starting from scratch, use the annotation to help understand how Zenkit To Do organises your tasks into lists and folders. If you've previously used Wunderlist, you should find it's instantly familiar. The 'Import from other apps' option enables you to bring across your Wunderlist or Microsoft To Do account.



Organise related tasks together into Lists, which can in turn be filed into folders for efficient management of larger-scale projects.

Tasked with tasks

If you're starting from scratch, you'll notice that 'Add Task' appears under Inbox in the main central pane. Click this, give it a suitably descriptive name and then click Create. The task will now appear in the list – if it's a simple task, you can mark it complete by clicking the circle icon to its left. The task will be marked as Done and its title formatted with strike-through text. Changed your mind? Click the tick box again to mark it incomplete.

To edit the task and add some extra detail, click the task name and its resizeable Edit pane will appear on the right (click its left drag handle to increase or decrease its size). Here you'll see a series of fields – all optional – to flesh out your task further. Start by setting a deadline for the task: click Due Date and a calendar picker will appear. This makes it possible to either select from here or enter your date manually using the MM/DD/YYYY format.

Click Save and the due date will appear next to the task title in the central pane. The date will be coloured black while it remains in the future or present, then turns red when it becomes overdue. To help identify imminent deadlines, 'Yesterday', 'Today' and 'Tomorrow' are used in place of the actual date when appropriate.

You'll also see Reminder and Repeater options. Reminder means that you'll be nudged about the task at a specific time and date, while Repeater enables you to convert the task into a recurring one, with a new copy of the task created a daily, weekly, monthly or even yearly intervals, with an option to expire on a specific date or after a specified number of repeats.

Make use of Zenkit To Do's rich text support via markdown or HTML to put together descriptive notes to accompany your tasks.

Make use of Smart Lists

As your usage of Zenkit To Do grows, you'll start to notice more views appearing underneath the Inbox – these are so-called smart lists, automatically populated according to the status of your to-do items. For example, once you start adding deadlines to to-do items, you'll start to see time-sensitive lists such as Today or Week, enabling you to view items whose deadlines are approaching.

Other smart lists include Assigned to Me – for viewing tasks you've been allocated as part of collaborative projects – and Starred, which you can use to list specific tasks of your choice by clicking the star button at the top of a task's Edit pane. Items can belong to multiple smart lists, so if you've starred a task that's been assigned to you that's due today, it'll appear under all three smart lists.

When viewing a smart list, you'll see you can create new tasks. This means the criteria for adding the task to that list, such as deadline or whether it's starred, will be automatically pre-filled for you. You'll also see an option beneath the task title that enables you to choose which list to assign that task to.

Two additional smart lists are hidden by default: All and Done, the latter listing all tasks you've marked as complete. Make these visible (or hide any smart lists you don't want to see) by clicking your account icon (top right corner) and choosing Settings > Smart Lists.

Sub-tasks and notes

If your task comprises multiple parts, use the Add subtask… button to set these up. Subtasks can't be allocated their own due dates, but you'll see a new icon appear in the main view next to your task's due date. This shows how many subtasks there are, and how many have been marked as complete (you'll also see the task's title bar change colour as subtasks are ticked off).

Each task can be rounded off with a note and file attachments. Click inside the note and you'll be prompted to type into the space provided. This is fine for short notes, but you can record detailed notes by clicking the floating button to the right of your text to bring up a floating text editor window. By default, notes are recorded as plain text, but click the Plain drop-down to switch to HTML or markdown text. You'll see the formatting toolbar change

depending on which option you choose – look for handy shortcuts to formatting your text and inserting elements like hyperlinks and images (via web links).

HTML view also enables you to switch between visual and code view to allow the insertion of additional elements such as HTML headings. Markdown only provides a code view, so you'll need to click Save to see the fruits of your labours via the Edit pane.

Attach files

Click Attachments and a pop-up window will provide options for attaching any file to your task. You can drag and drop, select a file, insert from Google Drive, Dropbox or Box (you'll need to connect the relevant account first) or manually enter a link to a file stored online.

Image attachments will pop up with the filename and a thumbnail of the image underneath it. Click the thumbnail to view a larger version as well as access a 'copy link' option (which you can then use to embed the image into the task note if you wish). Roll your mouse over the image to reveal alternative options: rename it, download a copy to your hard drive or delete it. There are no individual limits to the size of files that you can attach to your items, but Free users are limited to 500MB of attachment space in total.

Beneath the attachment section you'll find Comments and Activities. The former can be used to keep tabs on an item's progress, while Activities contains a record of all changes, with an option to 'reply' to the activity in the form of a comment. Both features come into their own when making use of Zenkit To Do's collaborative features – more on those shortly.

Get organised

While subtasks are useful, their lack of options makes their use limited. This is where Zenkit To Do's additional layers of organisation come into their own. Individual tasks can be stored in lists – for example, you might have a list of household chores, or list of items you need to work through to build the perfect home server. Lists also enable you to work collaboratively with others.

Use the 'Create List' on the left to set up your first list. You'll be prompted to give it a name, and you'll also see options for adding members. The final option makes it possible for you to subscribe to the list – see the Subscriptions box for details on how this works. Click Create and a new list will appear in the left-hand menu under Inbox and Search.

Select the list and you'll be able to create new tasks directly inside it. You'll also see a Share button next to the title, enabling you to retrospectively share the list (and all its tasks) with other Zenkit To Do users. But what about existing tasks? Navigate back to Inbox, where all unfiled tasks reside, then right-click your chosen task and choose 'Move to List'.

You can add a further level of organisation in the form of folders, inside which lists are stored. Right-click a list and choose 'Move to new Folder'. Give it a name and click Create. Once created, you'll see the folder appear with the list inside it. Click the + sign next to the folder name to create new lists inside it, and … to access additional folder settings.

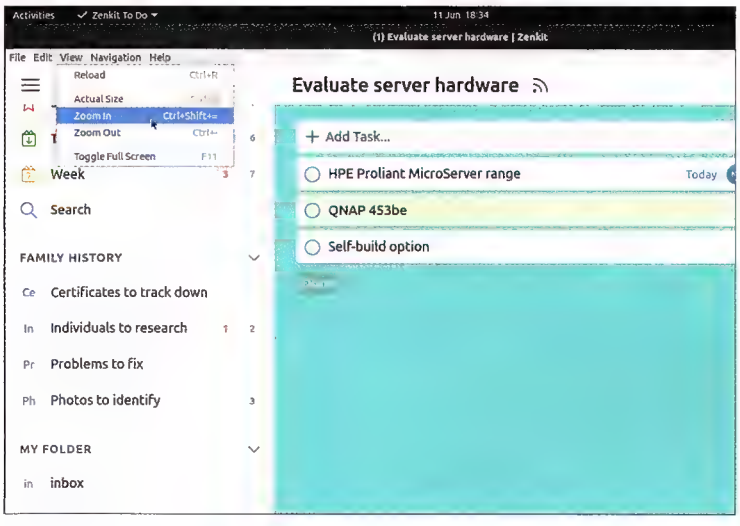
From Settings you can add a description, and give other users access to the folder (and all its contents). You can even transfer ownership of the folder to someone else too – perfect if you're passing the reins of a project to someone else.

Other users

The step-by-step guide (right) reveals the key things you need to know about project collaboration using Zenkit To Do. Free users can

QUICK TIP
You can archive single tasks and entire lists – just right-click the item and choose Archive to hide them. To reveal an archived task, right-click its parental list and choose Settings > Archive; lists are restored by clicking … next to their parental folder and navigating to Archived Lists.

If you're running the application either full-screen or on a high-resolution display, use View > Zoom to make text more readable.



Stay updated via subscriptions

If you want to keep appraised of any changes made to a task or list by other users, subscribe to ensure those changes are faithfully recorded and alerts sent via the main notifications tool. To subscribe to an individual task, just right-click its title (or click the … button in its Edit pane) and choose Subscribe. To subscribe to a list, right-click it and choose Settings, then flick the Subscribe slider so it's turned on.

These notifications are delivered via the main Notifications tool (the bell icon) by default. To edit how subscription notifications are delivered, choose File > Settings > Notifications. When you do this you'll see options for both Activities and Comments. Click one and flick the switches as required.

Keeping track of which lists and items you've subscribed to might be tricky if it weren't for the fact you can view and manage them all via Manage Subscriptions, which you'll find in the same Settings > Notification dialog. Click this to see both lists and task names you've subscribed to. Click X next to any of these to immediately unsubscribe from future notifications.

You'll also see an 'Automatically subscribe me to tasks I am assigned to' switch. Flicking this to on ensures you'll be made aware of any changes other members make to tasks you've been allocated.

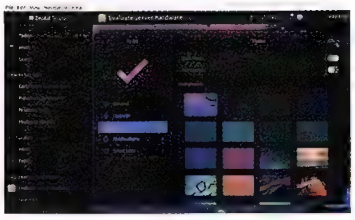
invite up to two additional members (so three members in total) to access a list or folder, but are unable to control the level of access members have, so bear this in mind. You'll need a Plus subscription if you wanted to remove their ability to manage other members, edit tasks or even post comments.

As you get into conversations with other members, you may feel irritated at being bombarded with notifications from all directions: within the program itself, on your mobile (if you've installed the mobile version of Zenkit To Do), via Linux's own Toast notification system and even by email.

To manage notifications, click File> Settings> Notifications. Here you'll see three basic notification options: General, Reminders and @Mentions. Click one and you'll find five switches covering all the options.

@Mentions has all five enabled by default, so it's a good idea to disable two or even three to reduce the number of notifications you receive. The Notifications dialogue is also where you can manage your subscriptions.

Zenkit To Do supports a dark mode. Avoid the transparent settings on patterned backgrounds – text is too difficult to read.



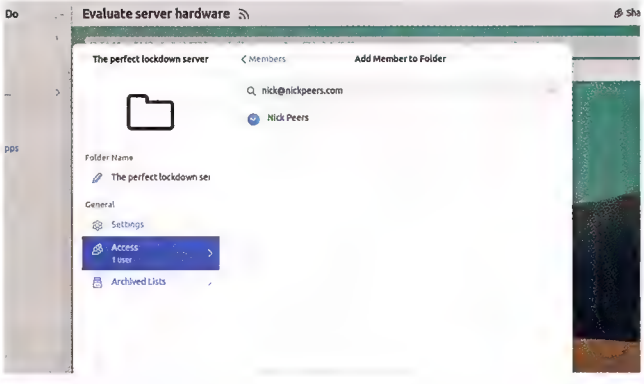
QUICK TIP

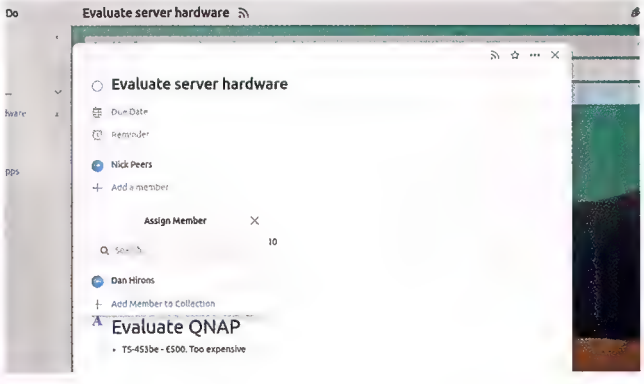
You have until 15 November 2020 to import your Wunderlist data into Zenkit To Do – see **https://export.wunderlist.com**. Once downloaded, unpack the zip file, then select Import from other apps > Wunderlist Import in Zenkit To Do.

A fresh new look

You can customise the ZenKit To Do interface via File> Settings> Themes. You'll see two switches for toggling between light and dark mode. Flick Transparent on and off to make the navigation and edit panes semi-translucent. You'll also see no fewer than 43 alternative backgrounds you can choose – including nine plain options. Scroll all the way down and you'll see that if you want to import your own custom background, you'll need to upgrade to a Plus subscription. Visit **https://zenkit.com/en/todo/pricing** to find out what else you'll get with a Plus subscription, with prices currently costing US$4 a month. Upgrade through the main Zenkit To Do program (File>Settings>Upgrade).

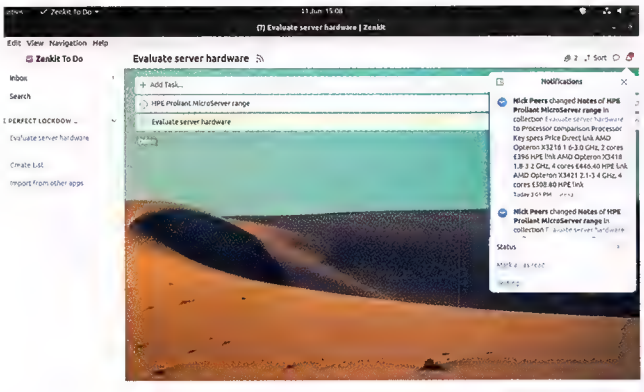
HOW TO Collaborate with other users





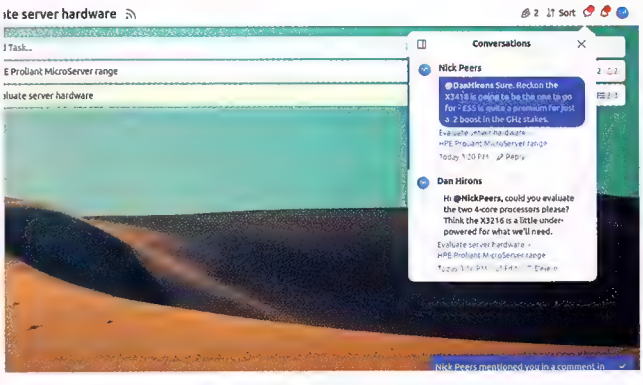
01 CHOOSE WHAT TO SHARE AND SEND INVIT

Collaborating with other users is done at the list or folder level. Look for the Add Member button (it's under Access in a folder's properties window for example) – click this, then type the person's username or email address. If they're already a user, they should appear in the list. Click their name to add them; if they don't, use the link to send an invitation.



02 ALLOCATE TASKS

Once a list or folder has been shared, click a task and you'll see a new option has been added to it in the Edit pane: Assigned to. Click this and you can allocate responsibility for completing the task to a specific member (or members). The person's name will then appear next to the task, but any member can still edit it or mark the task as being complete.


Conversations
Nick Peers
Dan Hirons
Hi @NickPeers, could you evaluate the two 4-core processors please? Think the X3216 is a little under-powered for what we'll need.

03 MONITOR UPDATES

If you've subscribed to folder or list updates, you'll be notified every time a team member makes a change. Look for the notification (bell) icon, both at the top of the screen and next to specific lists. Click one to review a list of changes. Click Read to mark it as read, then click Status to filter the list so only unread items are shown.

04 CHAT VIA COMMENTS

Select Comments in the Edit pane window to open a dialogue with other team members. Click @ next to the Send button to directly address a specific member, who can then reply via the Conversations button at the top of the main Zenkit To Do window as well from within the specific task (you'll be alerted via a pop-up notification).

RASPBERRY PI MASTERCLASS

Learn how to program the $1 chip

For the ultimate in low-cost embedded applications, the PIC microcontroller takes some beating. Mike Bedford shows you how to program it.

With the entry-level boards in Raspberry Pi family costing less than $5, we're fully conversant with the low cost of computing power. Yet if you've not encountered them before, the price of chips in the PIC microcontroller range from Microchip Technology might still be surprising. The fact is that an entry-level PIC chip can be bought for about 80 cents. Remarkable!

Needless to say, these chips don't offer a lot of processing power – in fact many of them wouldn't even be able to support an operating system. Yet in many embedded applications – that's where the processor works invisibly in the background – the requirement for number crunching is minimal, and an operating system is unnecessary. What's more, as we're about to see, those cheap chips contain a lot of circuitry that you might expect to be external to the processor.

Here we introduce you to PIC microcontroller chips and show you how to program them using the MPLAB Xpress IDE and a Curiosity development board. Although real-world applications of PIC devices involve using just the chip, which you'd incorporate into your own circuit board, using a ready-made board for learning to develop code offers a simple, ready-to-go solution at low-cost.

A key thing to bear in mind about PIC chips is that they're microcontrollers, not microprocessors. This means that they're effectively microprocessors with the addition of on-chip RAM, flash storage, non-volatile program memory, and input/output circuitry for interfacing to real-world devices. For this reason they can be used in embedded applications with a minimum of external circuitry.

Daddy or chips?

According to manufacturer Microchip Technology, there are several official families of PIC, but to cut a long story short, eight-, 16- and 32-bit architectures are available. Within each of these broad categories, specific products differ mostly in the amount of each type of on-chip memory and the number and type of I/O pins.

Some top-end chips, which are intended for signal processing applications, have the addition of DSP instructions. However, at the other end of the spectrum are chips that are aimed at applications where low cost and a small size are the most important considerations. For example, the PIC10F200-I/OT is an eight-bit microcontroller that runs at a clock speed of 4MHz. It has 256 bytes of program memory, 16 bytes of RAM, and four digital I/O pins. The chip is tiny, having just six or eight pins and, depending on the package type, measures as little as 2.8x2.9mm.

Development kit

If you're using a PIC chip in a real application, the most common way of using it would be to incorporate it into your own custom circuit board, as opposed to using an off-the-shelf SBC. This way you can minimise space and cost. However, so you don't have to carry out any electronic design or construction at this early stage – we're basing this tutorial on a development kit from Microchip Technology.

Called DM164137 Curiosity, and costing about $40 (try **digikey.com.au**), it has a socket into which you can plug any eight-bit PIC with eight, 14 or 20 pins, although it's supplied with a PIC16F1619 already fitted. However, if you do want to use a different PIC chip, code is portable between eight-bit devices, often with no change or minimal alteration. The PIC16F1619 is an eight-bit chip which is clocked at 32MHz, it has 8K of 14-bit program memory, 1K of RAM, 128 bytes of non-volatile user memory and several timers. Turning to interfacing options, it has 18 I/O pins which, in addition to standard digital input and output, support I²C, LINbus, SPI and UART/USART interfaces, there are two PWMs (Pulse Width Modulators), there's a 12-channel 10-bit ADC for analogue inputs, and an 8-bit DAC for analogue output.

You might be more used to processors having hundreds of connections or more, but this tiny eight-pin PIC chip is a processor with on-chip memory and I/O.

There are several advantages of using the development kit. First it has a USB port so you can connect it to a PC. When it's used with one of the microchip integrated development environments, you can program the on-board PIC by downloading your code into the chips' non-volatile program memory, and it also provides debugging facilities.

Second, it has various devices connected to the PIC's I/O pins. In particular, it has a mechanical push button (actually there are two, but one is specifically to reset the board and can't be read by software), a capacitive "mTouch" touch-sensitive switch, a potentiometer that feeds a user-controlled variable voltage to the PIC, and four LEDs (in addition to a couple of dedicated ones such as a power indicator). In addition, there are also headers that provide a means of connecting to any of the PIC's pins, thereby enabling other I/O options to be used. There are also two so-called footprints, which are groups of holes in the board to which the user can solder modules or connectors. One of these supports a Bluetooth module, while the other, the mikroBUS footprint, allows one of a variety of Click Board sensors to be used. A huge selection of these boards is available from Mikroe (**www.mikroe.com**).

Feeling curious?

Now you know what Curiosity does, it's time to try it out for yourself. We'll be referring to where on the board you can find various LEDs, pushbuttons and so on. When we do that, our instructions will only make sense if you're holding the board with

the side containing the majority of the components facing you, and with the words 'Microchip' and 'Curiosity' the right way up.

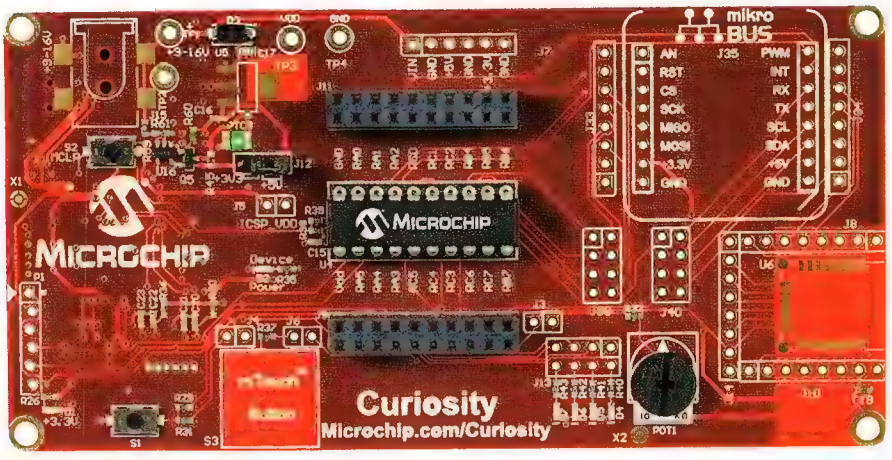
Curiosity is powered via its mini USB port, for which you'll need a USB A to mini USB B cable. Note that the cable isn't supplied with the board, and because the on-board socket is different from the micro USB socket on most Android phones, you can't use a common USB to micro USB cable. The board is supplied with a demonstration program already loaded into the PIC chip's non-volatile program memory, and this will run as soon as you connect the board to your PC and hence supply it with power. So, having plugged it in, check that it's working by adjusting the potentiometer, POT1 – that's the rotary control near the bottom right corner of the board – and, all being well, it'll control the brightness of one of the LEDs to the left of the potentiometer.

Try also putting your finger on the touch-sensitive m-Touch button, which is near the bottom left. This should cause another of the LEDs near the potentiometer to illuminate. Once you know that your Curiosity is working, it's time to get to grips with the development environment.

Microchip Technology's MPLAB X integrated development environment is a fully featured tool which is freely available for Linux. However, for first-time users, Microchip suggests using its MPLAB Xpress IDE, which is also free, cloud-based, and simplified compared to MPLAB X. In accordance with this recommendation, this is the route we took, although much of our advice will apply if you chose to use the locally-installed MPLAB X IDE.

Get started by going to **www.microchip.com/mplab/mplab-xpress** and clicking 'Get Started NOW!'. As you'll discover, however, although part of the suggested benefit of the cloud-based IDE is that it runs in a browser and therefore doesn't need installation, this is something of a simplification. In reality, a Java utility called the USB Bridge has to be downloaded and executed – and MPLAB Xpress will prompt you to do that at the appropriate time.

You might also need to install the latest version of the Java Runtime Environment, though, and because the USB Bridge is actually a .jnlp (Java Network Launching Protocol) file, you'll also need to install IcedTea. And finally, before we really get started, it's a good idea to register with Microchip and login to MPLAB Xpress. This will enable you to save your projects.



The Curiosity development kit gives you all the information you need to learn about PIC chips and how to program them.

As your first exercise, we suggest that you reprogram the PIC16F1619 on your Curiosity Board with a different ready-made program. To do that, click EXAMPLES in the toolbar and you'll be taken to a page on the Microchip website containing MPLAB Xpress examples. Under Board select Curiosity and search for PIC16F1619 under Device so you'll only see examples that are appropriate for your hardware.

One you'll see, and which we recommend, is called Curiosity - PICF16F1619 and it has a Microchip logo against it, indicating that is was provided by Microchip, as opposed to the user community. Click IDE to the right of that line and you'll be transported back to MPLAB Xpress, but now with that example code loaded into the IDE. Now, click the Make and Program Device icon in the toolbar, which looks like a PC screen with a green arrow pointing down to a chip. This causes the code to be compiled and loaded into the PIC chip's non-volatile program memory.

You can follow progress in the Debugger Console window and you might also notice that one of the red LEDs to the left of the potentiometer on the board flashing briefly – this indicates that the on-board non-volatile

QUICK TIP

Raspberry Pis are often used for control projects, even though they run an OS. PICs represent the ultimate in this progression, in being just single chips, even though companies have built PICs into SBCs, like the Curiosity development kit.

The PIC Instruction Set

For low-end chips with only a small amount of program memory, you might choose to program in assembly language instead of C. Here we're assuming that you've already done some assembly coding on a different processor and, for that reason, that you only need to learn about PIC specifics. You'll easily be able to do that as a self-learning exercise, but a few words on the peculiarities of the PIC 16 series instruction set will, hopefully, help you get up to speed.

Higher-end PIC devices differ but the thing you'll probably find surprising about PIC 16 series chips is that they don't have any conditional branch instruction such as BRZ (BRanch if Zero). Certainly the chips have the necessary status bits – specifically zero and carry bits – but a different method is used for conditional flow control.

There are four conditional flow control instructions, all of them causing the next instruction to be skipped depending on whether a condition is met. These are BTFSS and BTFSC, which execute a bit test followed by a skip on set or clear, respectively, and DECFSZ and INCSFSZ, which execute a decrement or increment, respectively, followed by a skip if the result is zero. In most cases, the instruction following the conditional instruction – the one that may or may not be skipped – will be an unconditional branch, with the result that a PIC 16 assembly program will be slightly more like the proverbial spaghetti code than assembly programs for most other processors.

program memory is being written to. Some SBCs that are used with an IDE on a PC run their code automatically as soon as it's been downloaded. With the Curiosity, though, you'll have to unplug it from your PC's USB port and reconnect it. This, of course, is a perfect analogy of what happens in real embedded applications – the code runs as soon as power is applied.

This demonstration code has several so-called labs, which are selected by pressing and releasing the pushbutton labelled S1, which is near the bottom left of the board, to the left of the mTouch button. To start, none of the labs will be running so you'll need to press and release S1 to select Lab 1, and you'll subsequently do the same to move from each lab to the next, cycling back to Lab 1 after Lab 10. You'll be able to see the output of each lab by looking at the four red LEDs (D4, D5, D6 and D7) to the left of the potentiometer, and the action of Labs 1, 2 and 3 will be obvious.

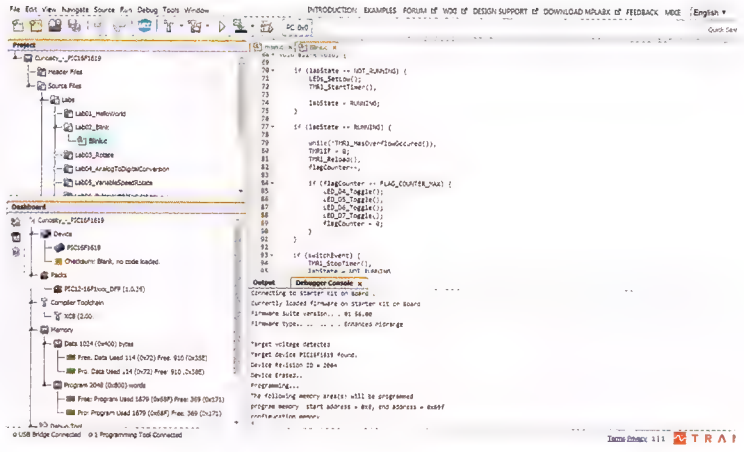
Lab 4 will only be exercised properly if you try adjusting the potentiometer and you'll then notice that the LEDs display a binary number related to the position of the potentiometer. In Lab 5 the LEDs rotate at a speed depending on the potentiometer position, and in Lab 6 the brightness of the left-most LED is controlled by the potentiometer. We're not going to get embroiled in the other labs because the descriptions are a bit more involved. However, if you do want to read up on them, click EXAMPLES again and on the line for the Curiosity - PICF16F1619 example, click the red title.

Programming Curiosity

The primary language for programming PIC chips – certainly the more powerful ones – is C, but it isn't our intention here to deviate from our topic of PIC programming by providing any instructions on coding in C. This being the case, if you're not sufficiently au fait with this language, you'll need to get up to speed, although at least the first of our suggested programming exercises are so trivial that not being proficient in C is no deterrent.

To help get a better feel for the workings of MPLAB Xpress, we'll make an extremely simple change to Curiosity - PIC16F1619 so that,

Like its big brother, MPLAB X, the MPLAB Xpress IDE provides all the tools you need to develop, execute and debug PIC code, and is the preferred tool for beginners.



QUICK TIP

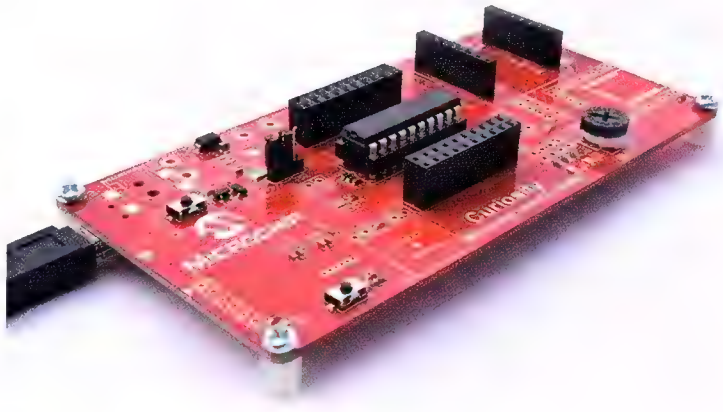
Our aim here has been to inspire you to try your hand at PIC programming, and present an overview of the process. But you'll need much more in the way of user documentation such as the XC8 User Manual, and perhaps PIC datasheets. Check out the wealth of information at **www.microchip.com**.

in Lab 2, the LED flashes at a different speed. First of all, though, let's just take a look at what's displayed on screen with the sample project loaded.

At the top left is an area labelled Project that shows, hierarchically, all the source and headers files associated with the project. Navigating around this is intuitive. You'll also notice, in the largest area of the screen, that the source file main.c is already open for you to view and edit. If you do take a quick look at it, though, you'll see that its function is nothing more than to increment the lab number as pushbutton S1 is pressed, and to call the appropriate function for the selected lab.

You'll also notice that, since we want to alter the speed of flashing in Lab 2, the function we need is one called Blink. You'll find the code for this under Curiosity - PIC16F1619 > Source Files > Labs > Lab02_Blink in the tree structure of the project, so click Blink.c to open it in a new tab in the main area of the screen. A one-line change is all we need to make. That line is numbered 58 and is a macro definition for a constant called FLAG_COUNTER_MAX , and which is defined as 3 to give a flash rate of 1.5 seconds. Try changing it to 1 to give a faster half-second flash rate, or to 20 to change the rate to 10 seconds. If you want more fine-tuning over the speed you'll need to delve elsewhere, and we leave that as an exercise for you when you've finished working through our other examples.

Next up we'll suggest another way in which you can alter the code and, while it's still simple, at least it involves adding a few instructions instead of just changing a single line. Our change is going to be to Lab 2 again, and we'll still see LEDs flashing so, if you've changed FLAG_COUNTER_MAX to a large value, we suggest, first of all, that you change it back to 2 or 3 so you don't have to wait too long to see things change. Next, go down to line 85 where you'll find a function call to toggle LED D4 . What we're suggesting is to add three lines after the one containing LED_D4_Toggle(); with the instructions LED_D5_Toggle(); , LED_D6_Toggle(); and LED_D7_Toggle(); . It's fairly obvious what should happen, but go ahead anyway and



When connected to a PC, the Curiosity board will be powered up and immediately execute the code in its non-volatile program memory.

try it out. Hopefully all four LEDs will now flash instead of just the one.

Rather than jump straight in at this point by creating your own project from scratch, we recommend that you continue in this incremental approach of amending the Curiosity - PIC16F1619 project in ever more ambitious ways. First of all continue modifying the labs to change their operation in various ways. Then, before moving on to a completely new project, how about adding a brand new lab, Lab 11, that performs totally new function. We're sure you'll have ideas aplenty.

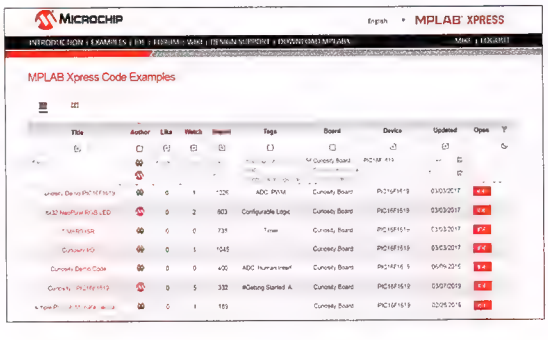
Before moving on to our next topic of assembly programming, we should tell you some news about MPLA Xpress that Microchip was keen to tell us. There's an improved version of MPLAB Xpress coming soon. Microchip is providing a GitHub interface for its community of users to store, collaborate and share their projects, and are moving the cloud services to scale for larger bandwidth. Apparently it's already started to release examples there and we'll see more of that in the time to come. It's possible, therefore, that some of the ways of working with the new IDE will differ slightly from the one we describe here, although we don't anticipate major changes and, after all, our primary aim has been to provide you with an overview of programming PIC chips, not a detailed tutorial on MPLAB Xpress.

QUICK TIP

We've concentrated on low-end PIC chips, but the range allows you to start with chips like the PIC16F1619 and work your way up as your needs increase. To give you an idea of what lies at the top-end, PIC32MZ family chips are clocked at up to 250MHz, they have up to 2MB flash and 512KB RAM, and have audio and video capabilities.

PIC assembly

Assembly programming might sound like something from the pages of a history book but this isn't necessarily true in the world of PICs. C code is rarely going to be as compact or efficient as assembly code, although this is often considered a price worth paying for convenience of high-level language programming with more powerful processors. However, if you've writing code for a chip with just a few hundred bytes of program memory, you might feel the need to bite the bullet and abandon C in favour of assembly code for smaller and faster code. We say a few words about the PIC 16 series instruction set in the box (above), but here we'll take a quick look at how to program in assembly in the MPLAB Xpress IDE.



Modifying sample code is a good first step in learning PIC programming, and Microchip Technology provides several examples for you to choose from.

To use the PIC assembler instead of C, go to Project Properties in the File menu and then, under Compiler Toolchain, select mpasm. Now, whenever you create a new file it'll be given a suitable extension and it'll be passed over to the assembler, rather than the C compiler, when you come to build the project and program the PIC chip.

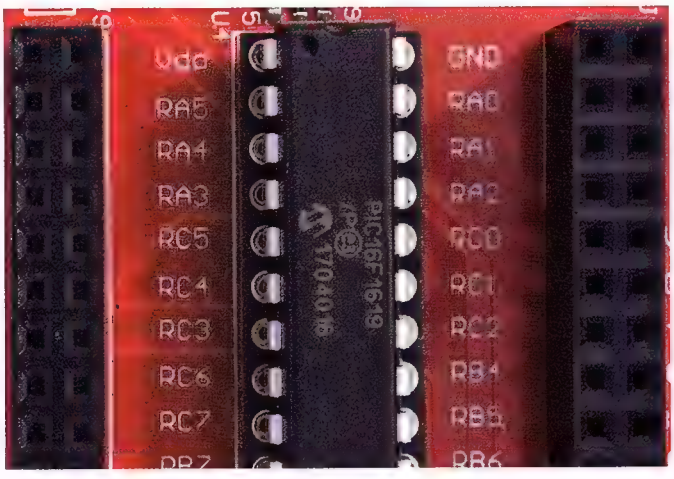
You might also be interested to learn that the XC8 compiler, which is MPLAB Xpress' default C compiler for eight-bit PICs, enables you to use inline assembly code in a C program. This can be achieved by placing your block of assembly code between a #asm and a #endasm. However, for compatibility with the latest standards, this is now discouraged and instead, you're advised to use the asm statement. Unfortunately, however, this makes the code look more untidy, and it's more laborious to write, with each line of assembler looking rather like this example: asm("DECFSZ COUNT"); . Use inline assembler with caution, though, because altering the contents of a register could cause the surrounding C code to fail.

IP Address Classes

Although we're using a Curiosity board to provide an easy way to learn about PICs, if you were to use such a device for a real-world project, you'd be relying on nothing more than a bare PIC to provide your computing resources. That chip would be incorporated into your own circuit board, the other on-board circuitry being non-computing hardware controlled by the PIC. This being the case, a Curiosity provides an ideal way to get a feel for this sort of application.

If you look at your Curiosity board, you'll notice that there's not a lot of hardware on the board except for the PIC chip, the circuitry on the back of the board being mostly required for interfacing with your PC so wouldn't be required for most embedded applications. In that respect, Curiosity isn't much different from a board that you might design, except that it doesn't have your program-specific hardware on-board.

However, you'll see that Curiosity has headers adjacent to each of the PIC's pins, which serve much the same purpose as the GPIO headers on a Raspberry Pi board. In other words, you can easily wire up a bit of external circuitry, probably on a breadboard, and connect it to the PIC chip. Do bear in mind, though, that Curiosity uses female headers while RPi uses male headers, so you'll need different patch leads.



Headers enable you to connect your own circuitry to any of the PIC's pins, providing the perfect way to learn about interfacing.

PSU 301 – Why PSUs always use protection

OPP, OVP, UVP, OCP, OTP, SCP – PC power supply units are three-letter acronym heaven. But what do they actually mean? Darren Yates explains your PSU's protection systems.

Your PC's power supply unit has one job to do – and that's convert the 240VAC AC mains power generated by the power utilities into DC power your PC components can munch on. The vast majority of the time, it all works smoothly, but on the rare occasion something electrically goes wrong in your PC, you want to know that problem won't cause you even more grief. That's the job of the myriad of protection systems inside PC PSUs. But what do these protection systems do? That's what we look into this month.

Stuff happens

Mistakes are made, components die, computers fail – not often, hopefully, but it does happen. That's why electrical engineers design in safety measures into PSUs, so that when things do go wrong, you've got some technology barriers to minimise the damage. For example, if a motherboard component fails, you want the system to hopefully shut down before it fries your SSD.

Voltage Rails

Your PC requires different voltages for different jobs and for this, your PSU delivers different voltage supplies or 'rails'. The four key rails are +12V1DC, +12V2DC, +5VDC and +3.3VDC. The +12V1DC and +12V2DC rails both supply 12-volts DC voltage, the +12V2DC rail usually feeding the four-pin ATX/EPS12V CPU plug.

Each rail supplies a level of electrical current measured in amps proportional to the overall power rating of the PSU. For example, the Seasonic S12III-650 will supply up to 20-amps of current on the +3.3VDC and +5VDC rails, up to 54-amps on the combined +12VDC rail.

There are two key points here – first, each voltage rail must supply the rated voltage and ideally, it should never deviate from that. So, the +3.3VDC rail must supply +3.3VDC. In practice, however, you never get zero-deviation and the ATX12V PSU specifications allow the voltage on each rail to vary over a small range. For these four rails we've mentioned, it's +/-5%. That means the +5VDC rail, for example, can drop no lower than +4.75VDC and go no higher than +5.25VDC. For the +12VDC rails, the lower bound is +11.4VDC and the upper, +12.6VDC. PSUs also usually have two other rails – a +5VSB rail and a -12VDC rail. The -12VDC rail is optional and only delivers a small current output, while the +5VSB is a 'standby' rail delivering up to 2.5-amps on a 650-watt PSU.

The second point is that a PSU should not be made to deliver more current than it is rated for. Remember in *Iron Man* near the end when Tony Stark tells Pepper Potts to "throw open all the circuits" on the arc reactor and it blows itself to bits? Dial the idea back down to '0.01' and it's why overloading electronic components for any length of time is bad - depending on how great the overload, they tend to go 'snap, crackle, pop'.

Protection systems

At the start of this series, we talked about voltage, current and power. Multiply the first two together and you get the third. These three key parameters and ensuring they stay within rated limits is what most PSU protection systems are all about. They're baked into the current ATX12V v2.4 PSU specification, Revision 1.31, an easier-read version of which is available from Intel (**tinyurl.com/intelpsupdf, PDF**).

All up, there are six common systems that make up most PSU protection frameworks:

Over-Power Protection (OPP) – this kicks in when the total power being drawn from the PSU exceeds its maximum rating. In practice, the trigger threshold will vary from one manufacturer to the next because this is not strictly part of the ATX12V standard. It can typically be

Below Left: On your next PC build, choose your PSU first – don't leave it until last.

Below Right: Seasonic's S12III-650 voltage panel shows voltage rails and current outputs.

anywhere from 10% to 50% over maximum depending on the PSU.

Over-Voltage Protection (OVP) – this one is part of the ATX12V standard and triggers when the +3.3VDC, +5VDC or +12VDC rails exceed their nominal levels by roughly 25%. Interestingly, this over-voltage trigger level itself has a range. For example, over-voltage on the +12VDC rail can be considered 'triggered' if the voltage reaches a minimum of +13.4VDC up to a maximum of +15.6VDC. PSU makers choose somewhere in this range.

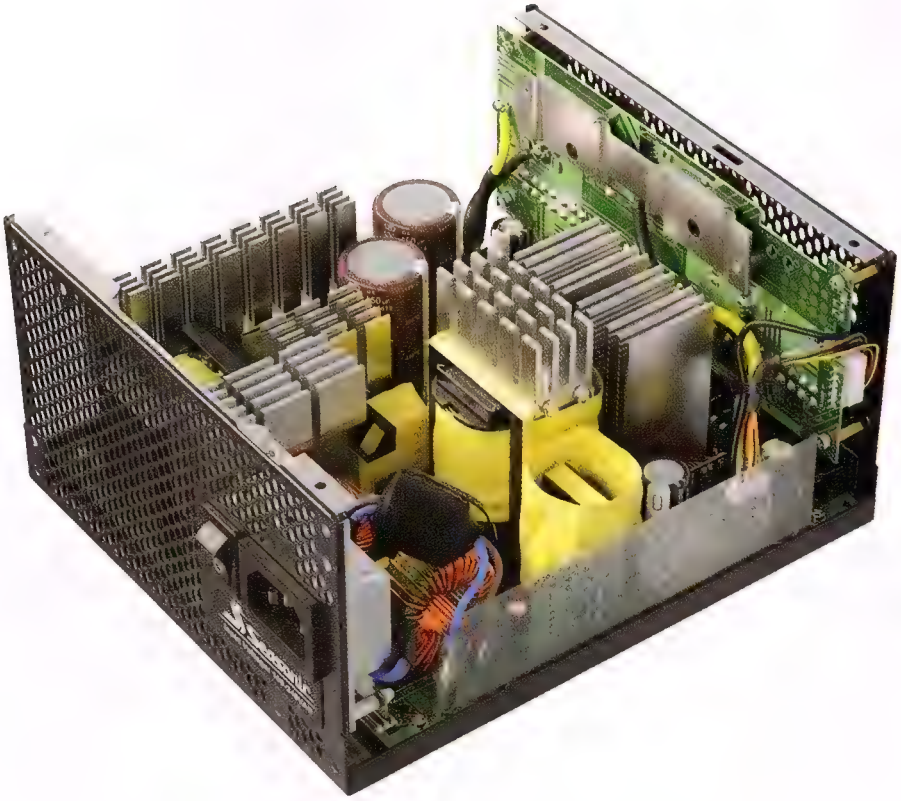
Under-Voltage Protection (UVP) – this is the other side of the OVP coin but again, is not part of the ATX12V standard, so it varies depending on the PSU manufacturer. Under-voltage can cause computer systems to crash, so it's not a good thing. However, under-voltage is typically less dangerous to electronics in general than over-voltage.

Short-Circuit Protection (SCP) – this is an important one and is included in ATX12V. A 'short-circuit' occurs when there is a low-resistance path from any supply rail to the zero-volt rail or 'ground' on a power supply. Short circuits can occur in any number of ways, so short circuit protection protects the PSU and your PC components by noting what's called the 'impedance' or the resistance of the electrical load on the PSU rail. If it falls below typically 0.1-ohms, SCP should come to the rescue.

These are the four protection systems you'll find on any decent PSU, but the better models will also include:

Over-Temperature Protection (OTP) – this is an optional extra according to ATX12V, but if you buy a fan-less PSU, it is a must. OVP is designed to trigger when the temperature within the PSU exceeds a preset trip level. Excess heat and electronics notoriously do not mix, so it's important that should the temperature exceed electrically-safe levels, the PSU shuts down before it blows up.

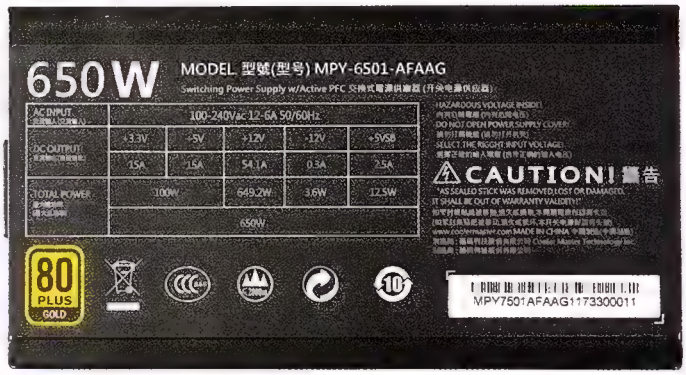
Over-Current Protection (OCP) – PSUs are rated to deliver a certain amount of current on each voltage rail and in some cases, the total rated current might be less than the sum of the two rails combined. For example, the Seasonic S12III-650 can do up to 20-amps on each of the +3.3VDC and +5VDC rails, but combined, the output power of these two rails cannot exceed 100-watts. So if the +5VDC rail is supplying 15-amps, that's 75-watts of the 100 gone (5x15), leaving only 25-watts for the +3.3VDC rail, or only 7.57-amps (25/3.3). The more expensive PSUs monitor output current levels and auto shut-down if levels exceed a trigger point, again, depending on the PSU and its manufacturer.



A fan-less PSU is all about avoiding over-temp, hence the cooling metal.

Safe computing

PCs are fun, entertaining and help many of us earn a crust, but given they spend so much time plugged into an AC mains socket, it's important they have the protection framework to ensure that the rare event of a component fail doesn't end up a catastrophic one. This is just one of the reasons why a good, reliable PSU should be the first PC component you think about, not the last.



Cooler Master's MWE 650 Gold has similar output to the Seasonic S12III-650.

Electrical Features	Operating Temperature	0 - 45 °C (derating from 100 % to 80 % from 40 °C to 45 °C)
	MTBF @ 25 °C, excl. fan	150,000 hours
	AC Input	Full Range
	Protection	OPP, OVP, UVP, OCP, OTP, SCP
Safety and Environmental	Safety and EMC	cTUVus, TUV, CB, CCC, BSMI, EAC, CE
	Environmental Compliance	Energy Star, RoHS, WEEE, ErP Lot 6, REACH
Warranty		12 Years

Can you name the Seasonic Prime Fan-less TX-700's six protection systems?

High profile streamers continue to shuffle platforms

Following Microsoft's closure of its beleaguered Mixer streaming service in July, high profile streamers are flowing back to their former homes. In August, both Tyler 'Ninja' Blevins and Michael 'Shroud' Grzsesiek commenced streaming on Twitch again, with the latter's return amassing upwards of 500,000 viewers. Shroud reportedly received a $10 million payout upon Mixer's closure, though it's unclear if he's struck a commercial deal with Twitch. Ninja hasn't struck any deal, either.

While Shroud chose Twitch because it's "the best," in his words, Dr Disrespect's recent ban from the platform is still a point of contention. For his part, Dr Disrespect has started streaming on YouTube, though in a statement provided to *PC Gamer* it was confirmed the popular streamer has no exclusivity deal with YouTubeas yet, and will likely experiment with other (non-Twitch) platforms in the future.

The foxes in *Ghost of Tsushima* have been petted almost 10 million times

According to a tweet from PlayStation, there were 8.8 million wonderful little fox pets in the 10 days since *Ghost of Tsushima* released. And since it's now been two weeks since launch, that number has likely climbed well upwards of 10 million. Give us an animal to pet, and you damn well better believe we'll pet it.

GAMING NEWS

The future of game streaming won't come to Apple devices

Apple confirms it won't host Microsoft's xCloud (nor Google Stadia).

Microsoft's xCloud game streaming service won't be available on Apple's iOS devices, despite a lengthy testing period on the platform. The reason, according to Apple, is that the company requires game software submissions to be reviewed on a title-by-title basis.

In a statement given to *Business Insider*, an Apple spokesperson claims the policy is designed to "protect customers and provide a fair and level playing field to developers."

It continued: "Our customers enjoy great apps and games from millions of developers, and gaming services can absolutely launch on the App Store as long as they follow the same set of guidelines applicable to all developers, including submitting games individually for review, and appearing in charts and search. In addition to the App Store, developers can choose to reach all iPhone and iPad users over the web through Safari and other browsers on the App Store."

Epic Games wields *Fortnite* as pawn in war against Apple and Google

The hugely popular battle royale is no longer available on iOS or Android.

Last month Epic Games brought its long-running tension with Apple and Google to a head: it installed a means for users to pay Epic Games directly in its *Fortnite* app for iOS and Android. This effectively denied Apple and Google of the 30 percent share they receive on every transaction made on the respective platforms.

The blowback was swift: in mid-August Apple removed Fortnite from its App Store, and Google followed suit several hours later. Epic Games responded by filing a lawsuit against both companies, and airing a little bit of agitprop in its game (downloaded by at least 250 million iOS users) entitled *Nineteen Eighty-Fortnite*.

It's hard to see what happens from here, but Epic Games CEO Tim Sweeney doesn't look ready to back down. "The fight isn't over Epic wanting a special deal," he tweeted, alluding to the company's protest against the 30 percent cut, "it's about the basic freedoms of all consumers and developers."

In its own statement, Apple wrote: "The fact that [Epic's] business interests now lead them to push for a special arrangement does not change the fact that these guidelines create a level playing field for all developers and make the store safe for all users."

Activision Blizzard says they'll share plans for next-gen game pricing "soon"

It won't be long before we hear how much Activision Blizzard's PS5 and Xbox Series X games could cost.

Activision Blizzard isn't quite ready to say how much their games will cost when the PS5 and Xbox Series X usher in the next-gen, but news on that front is coming shortly.

During the Q&A section of this month's quarterly earnings conference call, Activision president Rob Kostich was asked about the company's plans regarding pricing their next-gen games.

"What I'll say here is we'll be sharing our plans soon," Kostich said. "For now, we're just very excited for the launch of the new generation of hardware. We think it represents another strong leap forward in creating really incredible entertainment and value for our fans as we move forward."

This comes as Take-Two Interactive is grappling with the response from its own next-gen pricing model, which has *NBA 2K21* launching at US$70, an increase from current-gen pricing by US$10. Take-Two CEO Strauss Zelnick says the price increase is justified due to the "value" and "extraordinary quality" of their next-gen games.

Microsoft says there are no changes coming to the "experience" of Xbox Live Gold

So we can put those rumours to rest.

With persistent rumours painting otherwise innocuous developments in a curious light, Microsoft has now confirmed that it is not planning any major changes to Xbox Live Gold.

"The update to 'Xbox online service' in the Microsoft Services Agreement refers to the underlying Xbox service that includes features like cross-saves and friend requests," Microsoft told *GameSpot*. "This language update is intended to distinguish that underlying service, and the paid Xbox Live Gold subscription. There are no changes being made to the experience of the service or Xbox Live Gold."

In other words, that service agreement change was just what it appeared to be: a verbiage thing and nothing more. This statement will put to rest any rumours that Xbox Live Gold is being discontinued entirely in favour of a more unified online component. That said, the wording around "the experience of the service" leaves the door open for more incremental changes, which would be expected of any service adding a new platform – in this case, Xbox Series X – to its roster.

Call of Duty 2020 confirmed by developers Treyarch and Raven Software

Call of Duty 2020 is in development at studios Treyarch and Raven Software and will drop later this year, as both studios announced on Twitter.

"Activision will continue to build on its direct digital relationship with this expanded community as it delivers the next premium installment for *Call of Duty*, which comes from the wholly owned Call of Duty studios Treyarch and Raven Software," Activision said on an earnings call reported by *CharlieIntel*.

Move to ban US military from recruiting on Twitch fails to gain US House support

An amendment spearheaded by US Representative Alexandria Ocasio-Cortez to ban military recruitment on Twitch was voted down in the House Committee on Appropriations today.

The results were unambiguous: 126 voted in favor of the amendment, while 292 voted against it. The majority of those opposing the amendment were Republican at 188 votes, though 103 Democrats and one Independent also voted against changes to the bill. The majority of Democrats voted for the change, while Republican representatives were unanimously opposed.

Ocasio-Cortez took to Twitter after the vote, citing tech illiteracy as one of the factors contributing to the results. "It's totally fine if you don't know what Twitch is," she wrote. "But tech literacy is becoming a growing need in Congress so we can legislate to protect people's privacy." ■

apc HOT PRODUCT

$99.95 | PC, PS4 | deathstranding.com

Death Stranding

Become a post-apocalyptic postman.

It's best when *Death Stranding* shuts up. Being a game by Hideo Kojima, it's naturally filled with bizarre characters, lengthy screeds of exposition, and indulgent cutscenes. But it's in the long, quiet stretches between all this, when it's just you hiking alone across a stark, haunting post-apocalyptic wilderness, where it really shines. In these moments, Death Stranding is quite unlike anything I've ever experienced in a game – or any other medium for that matter.

That's not to say there's no value in the plot. When you're not being bombarded with backstory, it's pretty interesting – and deeply weird. You are Sam Porter Bridges, a courier delivering cargo across what's left of the United States. A supernatural cataclysm called the Death Stranding has driven the last of humanity underground, leaving the surface plagued by soul-sucking ghosts called BTs and rain that ages anything it hits.

Your mission is to hike across North America, connecting scattered settlements as you go. Why Sam, though? He's a talented porter with a reputation for getting things delivered on time. But, more importantly, he can detect otherwise invisible BTs with the help of a tiny, creepy baby strapped to his chest.

The majority of your time in *Death Stranding* is spent out in the open, plodding slowly from one place to another. It's essentially a feature-length fetch quest. But the environment, and the challenges it throws at you, makes these trips worthwhile. The landscape is serenely beautiful, with a grand sense of scale and a bewitching atmosphere.

But it's not just for show. *Death Stranding* is secretly a brilliant hiking and mountaineering simulator, and every piece of rough terrain you encounter is a puzzle to be solved. If you rush things, Sam can trip, stagger, lose his balance, get swept away by powerful rivers, or slide down steep inclines – losing or damaging cargo in the process.

Some jobs seem impossible at first. Standing at the foot of a mountain, snow whipping at its peaks, fragile cargo stuck to every inch of your suit, you wonder how you'll ever get over it. Along the way you might have to slip into *Metal Gear Solid* mode and sneak past BTs, or deal with extreme weather, including disorientating blizzards.

Disappointingly, story is *Death Stranding*'s weak link. The broad strokes are great, and Sam's mission to connect a fragmented civilisation is an effective hook. But so much of the finer details are told in uninteresting ways, whether it's through lengthy cutscenes, overlong text-heavy emails, or rambling radio chatter.

ANDY KELLY

Slow, weird, and indulgent, but a true original, and a journey that will linger in your mind long after it's over.

★★★★½

$84.95 PC, PS4 XB1, Stadia | codemasters.com/game/f1-2020

F1 2020

Bringing together a decade of evolution.

Being an F1 driver must mean a lot of weight to carry on your shoulders. When thousands of hours have been poured into crafting your race car, imagine having to face your boss after shoving it into the wall on lap one. Well... what if you are the boss? *F1 2020* lets you be driver and manager of your own team, so you can ignore your own inadequacy and instead punish disgruntled aerodynamic staff by closing their R&D department.

The F1 series has offered comparable depth in its career mode for a few years now, but creating and managing your own team really does make a difference to the emotional attachment you'll feel. From press interview answers and sponsor choice to how you fill the new calendar with off-track events, everything fits together with existing systems to create a cohesive whole. But most brilliantly, everything eventually comes back to how you drive the car, which is of course paramount in what is still very much an action-packed racing game.

While the more authentic session options and car setup details are likely to be overwhelming and too restrictive for newcomers, the new 'Casual' driving option and ability to turn down all of the deeper elements mean you don't need to be a fan to enjoy the superb driving. And anyone can enjoy the TV-style presentation, impressive dynamic weather system, and incredibly detailed slow-motion replays.

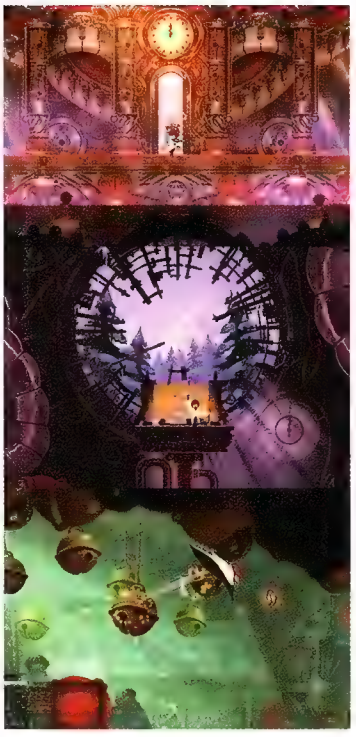
The driving engine certainly isn't the most realistic by any means, and the movement of the cars in the replay scenes still doesn't look exactly like real footage, but it plays beautifully all the same. While the racing has all the depth of last year's game, the new 'Overtake Button' simplifies the ERS system to essentially give you a turbo button that needs to be recharged, giving the close racing a fun, tactical twist. The now-ubiquitous rewind option is still there if you make a mistake but, as always, relying on it too much makes the game far less rewarding.

Still, the overall package is magnificent. It's simply a superb racing experience.

JUSTIN TOWELL

The deep career mode is even better when managing your own team, but the tactical racing shines brightest.

★★★★☆



Free | PC | bit.ly/SymphoniaGame

Symphonia

Another string in your bow.

It's a music-themed platformer set in a sumptuous concert hall, stuffed with platforms and spikes that will kill you in one hit. There are no enemies to fight, but the later jumping challenges are difficult, requiring masterful use of your high jump and wall-hanging powers.

In most games you simply tap jump again in mid-air, to give your character additional height, but here you have to physically whack the ground with your violin bow, to perform a bigger leap – a nifty little ability that takes some skill to use, particularly on temporary platforms. Moreover, it looks, sounds and feels just lovely to bounce off the ground this way. We're always jumping on or off platforms in games, but rarely does it feel like we're making tactile contact.

You could tell me this student-made project was a demo for a big-budget platformer and I'd believe you, so well-crafted is the orchestral music, the precise physics, and the fluid animation. The acrobatic little violinist is a well-defined character, brought gracefully to life, while the detailed backgrounds are a consistent visual treat.

TOM SYKES

A fun-size platformer that feels great to control.

★★★☆☆

Free | Browser | tora-group.itch.io

Tyrant's Realm

Demaking Tyrant's Realm.

Dark Souls but sci-fi. *Dark Souls* but 2D. *Dark Souls* but rubbish. I do enjoy a good *Dark Souls* clone, and here's another in *Tyrant's Realm*, which is *Dark Souls*, but made for the PS1. Not literally, obviously, but this retro-styled action game is surprisingly convincing, boasting the jagged polygonal look, the slightly awkward combat system, and even the level design of a 32-bit game. The only thing letting it down is the framerate, which is disappointingly rock-solid, as smooth as velvet. Real PS1 games ran at 14fps, and we loved every chunky second.

Similar to *Souls*, you'll biff baddies in third-person as you explore a medieval prison, stopping occasionally to chug a potion. Where other *Souls*-likes try to move the genre forwards, or at least sideways, by adding new features or swapping out the setting, TR's backwards step feels oddly refreshing. By adopting not just the look but the philosophy of a PS1 game, it's a leaner, less cluttered experience, and perhaps a good place to start if the stingy nature of the other *Souls*-likes has scared you off.
TOM SYKES

Similar to, but different enough to *Dark Souls* to make it interesting.
★★⯪☆☆

$49.95 | PC | revolution.co.uk

Beyond a Steel Sky

Building a LINC to the past.

The 1994 adventure game *Beneath A Steel Sky* was considered quite good (like 91 percent good), and to call it fondly remembered would be an understatement. And now, in 2020 of all years, it gets a sequel.

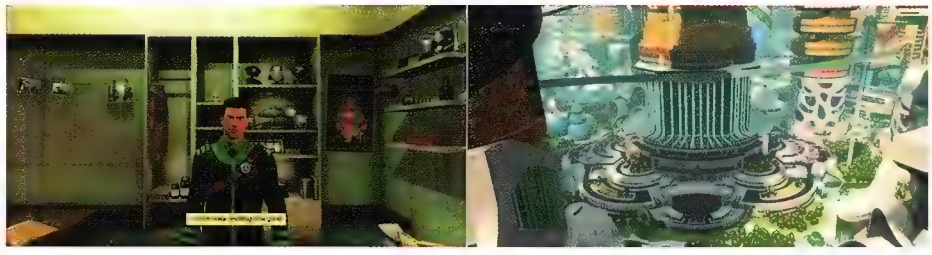
The last time protagonist Robert Foster was in Union City it was under the benevolent authority of his pal Joey. Ten years later, he's dragged back to find it's now under the control of The Council, and that everyone is really happy. They've got to be, because their lives hang on their Qdos scores. It's nudge theory run rampant, as things like turning up for work and taking part in daily votes alter your score, which affects where you can go and how low in the towering arcologies you can live.

Of course, this world of hi-tech Eloi and Morlocks wouldn't be the same without a dark secret. Layers of high crimes and misdemeanours peel back to expose the twisted logic at their core like something from a monstrous episode of *Black Mirror*. While *Beneath A Steel Sky* showed that a sick society could be saved by a good man (or robot), *Beyond* sees a utopia exposed and torn down, the nobility of its characters setting them against one another.

Considering the enormous shadow it chooses to live in. It burns brightly in spite of this – the lightly cel-shaded art has never looked better, and the update from point-and-click to WASD is a positive choice. The narrative wraps itself around that of the first game, although it doesn't matter if you haven't played it (but you should).

There are failures of logic, though, odd for a game whose denouement is tied up in paradox and reasoning. Puzzles can plunge into a maddening game of throwing every switch and trying every object with everything in your inventory. Moments of head-scratching are nothing new in adventure games and they do nothing to detract from the superb world Revolution has constructed. Is it a patch on the original? No: it's an upgrade.
IAN EVENDEN

Filled with what made the original game great, this second trip to Union City has been worth the 26-year hiatus.
★★★⯪☆



$28.95 | PC, PS4, XB1, Switch, Linux, Mac | carrion.game

Carrion

More gore and tentacles than your average *Carry On* entry.

We spend a lot of time running from rampaging monsters in video games, but rarely do we get the chance to play as the creature in question. Devolver Digital's latest retro-styled throwback, *Carrion*, let's you do just that, placing you in charge of a tentacle-covered alien monstrosity as you tear through the facility that imprisoned you.

Kicking off with your escape from a scientific chamber, *Carrion* sees you use your tentacles to traverse around large underground rooms in an incredibly fluid manner, as you attempt to escape your captors. Controlling the monster is fairly simple – use your left stick to move around, your right stick to control your tentacles, and hold the right trigger to grab objects (or hapless people) which you can then fling around. Although you start your journey as a small, pulsating mass of teeth-covered gore, you quickly begin to increase your biomass as you use those aforementioned tentacles to stalk and eat every human in sight (though not before violently bashing them around the environment a little bit beforehand).

In true *Metroidvania* fashion, your monster will need to track down and absorb DNA upgrades that will grant you new abilities in order to reach previously blocked areas. These include such powers as passing through lasers, reducing your size to smash through tight barricades, swimming through water, or even controlling the minds of humans to get into locked areas.

Those familiar with this beloved gaming subgenre will know that back-tracking usually takes up a large portion of your game time, and in this instance, *Carrion* proves somewhat frustrating due to the lack of any kind of map system. Thankfully, the game's short and sweet four-hour campaign length means you probably won't spend a great deal of time running around trying to figure out where you should go next. Minor setbacks aside, *Carrion* is an incredibly satisfying monster romp that will please horror fans who've always wanted to get their freak on.

STEPHEN LAMBRECHTS

If you've ever wanted to carry on like a real monster, *Carrion* is your game.

★★★★☆

Free | PC, Mac, Linux

radiatoryang.itch.io

Hard Lads

Testing masculinity.

A few years ago, some men got together and decided to whack each other with a chair among other very silly things. The resulting video went viral, and now Robert Yang has made a game about it: a sort of interactive YouTube clip that you can replay and replay in search of answers, much like the video itself.

You play as the cameraman (perhaps the least 'hard' of the group), and by clicking on-screen icons you can direct the men to smoke, to drink, to wield the chair and to kiss each other, all of which happened in the original video. You can then perform the actions yourself, by moving the mouse or analogue stick. You can make the smoking turn into a lung-clearing hacking up, by moving the analogue all the way, or you can transform that quick peck into a full-on snog.

Ultimately I got more from the original video – and Yang's essay about it – than I did this game, but it's a fascinating exercise in adding interactivity to a piece of found art.

TOM SYKES ■

It's a bold idea, making a playable version of a YouTube video, that sort of works.

★★★½☆

DEVELOPER EASYGAMESTATION PUBLISHER CARPE FULGUR RELEASED SEPTEMBER 10, 2010 WEB bit.ly/30LzS36

Recettear: An Item Shop's Tale

Steven Messner looks back at a humble precursor to the rise of Japanese PC games.

It's undoubtedly right to assume that *Recettear: An Item Shop's Tale* is one of the more important indie games that you've never have heard of. You see, it was the first Japanese PC game ever released on Steam, and its success helped kickstart a chain of events – including the release of *Dark Souls*' own hugely popular PC port – that proved there was an enormous demand for Japanese games on PC and not just consoles. *Recettear*'s developers thought it'd only sell 10,000 copies, but instead it sold over 500,000.

You wouldn't know it by playing *Recettear* today, though. Ten years is a long time, especially for an indie game, and *Recettear*'s adorable charm and engrossing loop of dungeon delving and bartering are now buried under some archaic limitations. For example, *Recettear* is only playable in one of four resolutions, and none of them are even close to being HD. There's no mouse support whatsoever, you can't adjust a lot of basic settings in the game (you have to launch a separate tool), and it defaults to using a bunch of nonsensical keybinds that will take a while to get used to. Ironically, playing *Recettear* now feels a lot like emulating a console game. I didn't mind it back in 2010 when I first beat it, and I don't mind it now.

"For years I had always played the hero and never given a second thought to the non-playable characters I found in every village and town. But Recettear is a game about all those item shop owners no one cares about."

That's because the charming *Recettear* is an easy game to love.

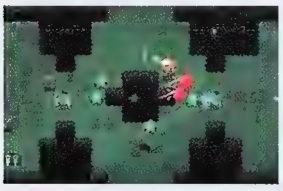
Selling out

Though it clearly borrows from PlayStation-era JRPG classics, *Recettear* isn't bogged down with a convoluted story. You play a young girl named Recette who runs an item shop alongside her friend-slash-loan-shark Tear, a fairy to whom Recette's father owes an enormous sum of money. To pay down that debt, Tear and Recette must team up and turn their plain, ugly item shop into a bustling business.

In 2010, this idea felt nothing short of genius to me. For years I had always played the hero and never given a second thought to the non-playable characters I found in every village and town. But *Recettear* is a game about all those item shop owners no one cares about. Today, that idea doesn't feel nearly as brilliant – partly due to so

Shopaholics

Three games to try if you like the idea of running an item shop



MOONLIGHTER
A spiritual successor to *Recettear* in many ways, but with gorgeous pixel art and Zelda-style combat.

WEAPON SHOP FANTASY
Similar to *Recettear*, but with more of an emphasis on producing weapons.

HOLY POTATOES! A WEAPON SHOP?!
Another item shop sim, except you hire potatoes to do all the work for you.

many other games having explored it – because *Recettear* also can't completely escape from the type of games it's trying to subvert.

Soon after running the shop for a few days, you unlock the ability to hire warriors to comb through dungeons and catacombs for treasure that you can sell. During these moments, which frequently take up half an in-game day, *Recettear* becomes a boring, basic dungeon crawler. It kinda sucks.

I didn't mind it as much in 2010, but I also think my expectations were a lot lower. But I've played dozens of dungeon crawlers since then (many of which were excellent), and *Recettear*'s stilted combat and basic enemies just aren't exciting enough to warrant the time it takes to kill them. I'd much rather be back at the shop, haggling over the price of a wooden shield with a customer.

Even so, I'm surprised by how easily I slipped back into that routine that once kept me up at night for days on end when I first beat *Recettear*. Days are divided into four 'slices' and different activities, like opening the shop or visiting the nearby Guild Hall for supplies, eat up a slice. Juggling these different activities is a lot of fun and it's easy to say 'just one more day' before realising three or more hours have slipped by unexpectedly.

Using the time you do have efficiently is important, though. Every few weeks Recette has to pay down a chunk of her father's debt to Tear, which creates a surprising amount of tension. Anyone who has had to scrape together money to pay rent will know that feeling – though *Recettear* covers up its depressing capitalist undertones with an *Animal Crossing* level of charm.

Even though much of *Recettear* hasn't aged gracefully, I'm surprised by how much I still enjoy it. It's a testament to how clever the core idea is, even if I could do without the mediocre dungeon crawling. It makes me sad that there was never a real sequel, because *Recettear* is quietly one of the more important Japanese games on PC. ■

MACHINE OF THE MONTH

Atari ST

John Knight looks back at one of *APC*'s favourite machines.

Regarded by many as the first proper 16-bit computer, the Atari ST was a powerhouse for its era and price. If you don't associate this kind of serious product with Atari, fair enough. This is not the same company that put *Pacman* into American living rooms – this was a new era led by the most bullish man in the business: Commodore founder Jack Tramiel.

Tramiel spent the early 80s aggressively expanding Commodore's market share, undercutting the competition. The results led to the Commodore 64 becoming the best selling computer of all time, but Tramiel's brutal methods were unsustainable and burned too many bridges. Commodore was sick of Jack, and Jack was sick of Commodore. Tramiel left in a huff in January of 1984.

Meanwhile, Atari was reeling from America's video game crash of 1983, bleeding a million dollars a day by 1984. Parent company Warner wanted to cut its losses, and Tramiel saw an opportunity, buying Atari's consumer division in July 1984. He kicked the company into shape in his usual aggressive style, firing almost everyone, and bringing a team of engineers snatched from Commodore to create a new machine. With Atari, Tramiel had an established name through which he could sell products and focus on developing a new computer.

Development

Tramiel had specific goals for his new machine: It would be 16-bit, powerful, cheap, and dramatically undercut Apple and IBM on price, while sticking it to Commodore.

Commodore 64 developer Shiraz Shivji was put in charge of the machine's design. For a CPU, National Semiconductor's NS32000 chipset was initially considered, but after witnessing disappointing performance, the team went with the Motorola 68000 instead.

Weirdly, pre-Tramiel Atari had already flirted with Motorola's 68000, with some key engineers wanting to make a 68000-based machine, but management wasn't interested. These engineers left Atari to start their own company, Amiga, and the computer Commodore would later buy and sell as its flagship model. In a strange twist of fate, Atari's engineers ended up working for Commodore, and Commodore's engineers moved to Atari.

For an OS, Atari rejected Microsoft's unfinished Windows 1.0 in favor of Digital Research's GEM (Graphical Environment Manager). After combining it with its underlying DOS, the environment was dubbed TOS (The Operating System). This simple and highly usable environment was similar to the Macintosh and often dubbed the "Jackintosh" after Tramiel.

While the team had originally planned to use a custom sound chip, time ran out, and Atari had to settle on a bargain-bucket Yamaha YM2149 chipset. To make up for it, Atari installed factory-standard MIDI ports, something that would turn out to be a 75-cent stroke of genius.

YOU'LL NEED HATARI

Atari ST emulator that supports a number of host platforms – get it from **https://hatari.tuxfamily.org**.

STEEM SSE

If a particular game doesn't run under Hatari, this is worth trying instead: **https://sourceforge.net/projects/steemsse**.

Atari's TOS interface may look horrible now, but there's a clean and simple elegance to these old operating systems.

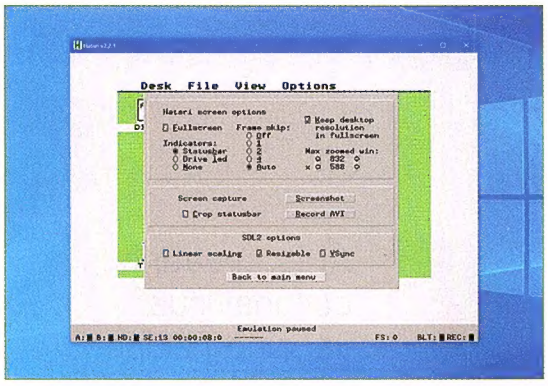
Launch

Released in June 1985, the Atari ST packed a Motorola 68000 CPU running at 8MHz, laid claim to 512K of RAM, and had a proper mouse-driven GUI. Arriving a month sooner than the Amiga, prices were $800 for a monochrome version or $1,000 for colour, around $500 cheaper than an equivalent Amiga.

TOS was a hit with consumers. Atari's high-res monochrome mode was popular with business users, and being able to buy an Atari ST with a printer and hard drive for less money than a single IBM printer made it popular with artists and publishers, too. Furthermore, it could use MS-DOS formatted floppies, and even emulate Mac software – faster than a real Mac.

The ST became an instant hit with musicians as well. Despite the cheap sound chip, when plugged into external MIDI, the Atari ST truly shines, with better latency than a lot of professional equipment. Programs such as Cubase started life on the ST, and its MIDI functionality is still used today by a number of high-profile musicians.

The ST had rapidly turned Atari's fortunes around, although it was only a niche player in the US, where IBM compatibles were dominant. The ST was far more popular in Europe (especially France), where it accounted for 75 percent of total sales – IBM machines were seen as too expensive, and TV-based micros were still popular. If you want a real



Hit F12 in Hatari to bring up the main settings screen. From here, you can switch to high-res monochrome mode.

Atari ST, buy an Australian or European model, because the PAL library utterly dwarfs the number of NTSC titles.

The gaming market was strong during its first years. Classics include 1987's first-person RPG *Dungeon Master*; Peter Molyneux's pioneering god game, *Populous* (1990); and 1993's tactical shooter, *Cannon Fodder*. However, support began to wane when Commodore introduced the cost-reduced Amiga 500, which had better graphics and sound than the ST, ultimately swallowing its gaming market.

Over the years, it released better machines to rival the Amiga, but neither company could compete with the PC market, which was growing cheaper by the day. Atari produced some 32-bit machines in the early '90s, but stopped making computers in 1993 in favor of a shift to consoles, and the ill-fated Atari Jaguar.

How do I emulate it?

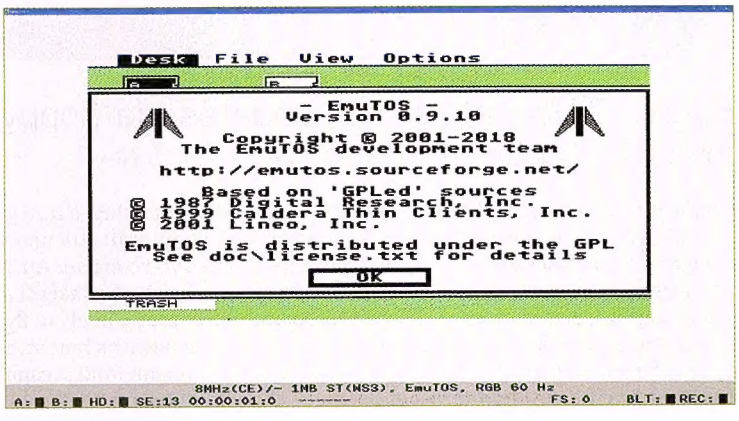
The first thing you should know about is EmuTOS (**https://emutos.sourceforge.io/en**). Most ST emulators require a system ROM (TOS) to function. EmuTOS is a free, open-source re-implementation of TOS that can run on original hardware (even some Amigas), or be used by emulators as a replacement system. It will suffice for most uses, but programs requiring obscure functionality may need an original system ROM.

The two most popular emulators are Hatari and Steem SSE. Hatari is probably the best choice, and it offers versions for Windows, Mac, and Linux (note that on the PC you may need to run it as administrator). Once loaded, you should hit F12 to configure a few settings, including where the two floppy drives point to, which will be any disk images you download.

The Linux version in system repositories will probably start with an error about the TOS file – licensing restrictions mean that a system ROM is unlikely to be included. You therefore need to specify a TOS file in the application's ROM menu, whether it be EmuTOS or a proprietary ROM image. Windows builds from the website come pre-loaded with EmuTOS, although you can use a proprietary ROM if you prefer (**https://hatari.tuxfamily.org**).

Steem (now Steem SSE) used to support Windows and Linux (**https://sourceforge.net/projects/steemsse**); newer versions only support Windows, but it runs well under Wine. Steem SSE requires a ROM image. We prefer Hatari to Steem, but if something doesn't work under one emulator, it's worth trying the other.

For lazy gamers RetroArch has a core based on Hatari, under "Load Core > Download a Core." ■



Hatari running EmuTOS: Not everything is going to work with this setup, but simpler apps should be good.

MEDWAY BOYS GAME MENUS

All these menus have come from my own collection or been submitted by enthusiasts to me.

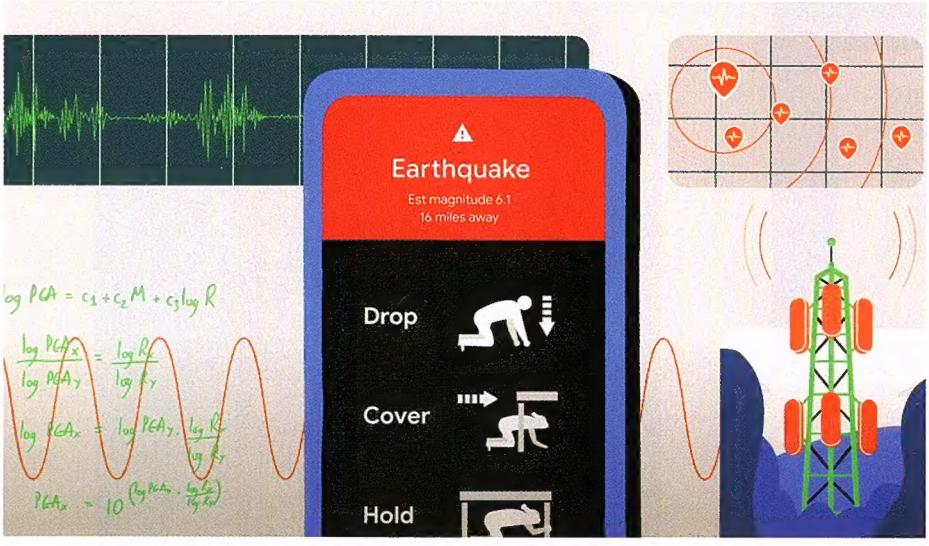
Where can I find software?

The obvious place to find games is via general ROM sites, but they are fraught with legal issues. These sites can also be a great source for system ROMs (TOS images in the ST's case), and switching between system ROMs can help get pesky programs running, but copyright issues still apply.

For visual demos and non-gaming apps, you usually need to look elsewhere. **Archive.org** has a few gems you can play with, and you don't have to sort through legally suspect ROM sites. However, the easiest way to find legal software of any sort is through magazine coverdisk archives, which usually mix gaming and utilities. We had most luck with Exxos's archive (**www.exxoshost.co.uk/atari**), which has a collection of disks from ST Format (a Future Publishing magazine that ran from 1989 to 1996). The collection is archived in .MSA format, which is easy to load, and compatible with Hatari.

CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS



Android becomes an earthquake detection tool

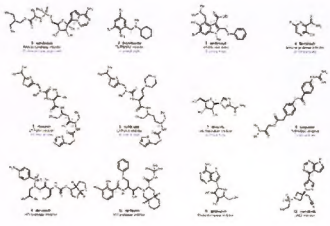
Android's new feature will rock your world... or at least tell you it's rocking.

While the accelerometer in your Android phone is generally used to track your daily steps, or help your GPS navigation be more accurate, Google says that it can also be used to detect earthquakes... if you have enough of them. Initially Google is just providing alerts for those in areas with existing earthquake detection, but once there is enough data the service aims to use networks of smartphones to provide alerts in areas without a local seismometer system. While individual phones are theoretically capable of detecting earthquakes, the network will increase the accuracy and information of event-detection.

Boeing 747s get critical updates via floppy disk

You think Windows 10 updates are tedious, hey?

On the off chance you had started to feel complacent about flying, a rare glimpse inside a recently decommissioned Boeing 747-400 has revealed the craft still updates critical navigation databases using 3.5-inch floppy disks. When you consider AirBus's latest planes are trying to integrate AI enough to have Auto-pilot complete the takeoff and landing sequences, it seems surprising that the aeroplane you're pretty likely to fly on still requires updates using a disk that holds less than your average email attachment. These databases have to be updated every 28 days by an exceptionally diligent (and presumably experienced) engineer. On the upside, you've got Buckley's chance of hacking them.



AI is creating coronavirus vaccine recipes

Researchers are developing a new technique to develop recipes for coronavirus medications that are currently being trialled to ensure they can upscale production quickly enough to meet the inevitable demand. Normally drug companies receive 20 year patents for new medications and can sell them at a price where manufacturing ease and cost have no need for efficiency, but a coronavirus treatment would need to be manufactured as cheaply and easily as possible to be able to benefit countries with less sophisticated medical manufacturing facilities.

Apple Watch gets Google Maps

The Cuppertino company has spent the better part of the decade standing behind Apple Maps, but it seems it's finally conceded that Google Maps would be a useful tool for Apple Watch and CarPlay users. The on-wrist version is not as full-featured as the iPhone app, only allowing you to get directions of previously saved locations or new destinations pushed to the devices from the iPhone application, but it will hopefully get some kind of voice integration in the future. The CarPlay version will also get new Dashboard functionality, which allows a split-screen map, turn-based directions and audio playback functionalities all on the one display. ■

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